MULTIPLE CROPPING MANAGEMENT OF CORN AND SORGHUM SUCCEEDING VEGETABLES

By
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To a couple of dreamers,

my grandfathers

Ladislao Mateo Esteban

and

Andres Valverde Amador

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MULTIPLE CROPPING MANAGEMENT OF CORN AND SORGHUM
SUCCEDING VEGETABLES

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In the Hastings area of Florida, potato (Solanum tuberosum L.) and cabbage (Brassica oleraceae L.) are grown during late fall and winter. The rest of the year, available resources such as solar energy, irrigation water, residual fertilizer from the previous crops, and equipment are not fully utilized by farmers. The planting of a second crop could possibly make use of these resources. Corn (Zea mays L.) and sorghum (Sorghum bicolor (L.) Moench) are alternative crops because Florida is a net grain importer and the ecological conditions are suitable for these crops. Several experiments dealing with production problems observed in the area (soil fertility, bed management, and cultivar evaluations) were conducted during 1977 and 1978, both in farmers' fields and at the Agricultural Research Center (ARC). The main objective of the research was to determine management needed for growing corn after cabbage, and sorghum after potato in succession cropping systems.

Experiments were planted on a Rutlege fine sand (Sandy, Siliceous, thermic family of the Typic Humaquepts). Drainage beds 1m apart were used to plant both crops. Factorial combinations of N(0, 100, 200, 300 kg/ha),

P(0,60 kg/ha), and K(0,60 kg/ha) were in a randomized complete block design. Soil and plant samples were collected before harvesting, and grain and total dry matter yields determined.

Nitrogen was the most important element affecting not only grain and dry matter yields but also nutrient relationships in all collected samples. In all cases the first N increment (100kg/ha) was sufficient to maximize yields. Phosphorus and K tended to decrease grain and dry matter yields in several cases, suggesting salinity problems and possibly nutrient toxicity. Nutrient content and correlations between soil and plant analyses are presented and discussed.

Use of the traditional 1.0 m potato bed resulted in an apparent waste of space and yield reduction for the sorghum crop. Several modifications of the 1.0 m beds were made and compared to 1.5 and 2.0 m beds in which various numbers of rows and broadcast treatments were included in a split-split plot design. Highest grain yield was obtained from the 2.0 m beds. The highest yield was obtained from the 2.0 m bed four rows treatment, which showed a 40% yield increase over the control. Total sorghum plant dry matter was also higher in 1.5 and 2.0 m beds. Highest N content was 175 kg/ha in 1977 for the 1.5 m five rows treatment as opposed to 76 kg N/ha in 1978 for the 1.5 m five rows treatment. Nitrogen removal in relation to N applied was 233% and 101% respectively for the two above mentioned treatments.

Cultivar experiments included 6 grain sorghum and 2 forage sorghum hybrids. Grain yield was difficult to evaluate due to missing values. However, grain hybrids Dekalb BR-54 and Grower ML-135 would probably be

the best choices for the area considering overall performance. There were no differences in the percent IVOMD in a combined 2 year analysis. The forage hybrids (Dekalb FS-25A and FS-24) showed the highest N, P, and K content values for both years. The importance of sorghum as a forage crop, probably needs to be stressed in this area. The percent N removed was very close to 100% by Dekalb FS-24. The total N, P, and K recycled by this forage sorghum was 74, 29, and 203 kg/ha, respectively.

INTRODUCTION

Today's energy problems are being dealt with and understood differently by various countries and individuals. The challenge posed to agricultural systems based largely on the use of fossil fuels has prompted agronomists to come up with alternatives to help alleviate the energy problem.

The use of multiple-cropping systems and minimum tillage are probably the most dramatic and successful examples of a new approach to incorporate ancient practices in today's modern agriculture. The key is not necessarily to intensify agriculture but to combine intelligently the available resources of land, growing period, and solar energy to obtain a larger output of food, fiber, and forage.

Florida has a full year growing period and a subtropical climate to expand production through multiple cropping. If innovative cropping systems are designed to better utilize the exceptional characteristics of the state and if practices like irrigation, weed, and pest control are carefully considered, it would be possible to maintain successful cropping systems to go along with the times.

This research was initiated with the above guidelines in mind. In the area near Hastings, Florida, potato (Solanum tuberosum L.) and cabbage (Brassica oleracea L.) are grown during late fall and winter. The rest of the year, available resources such as solar energy, irrigation water, residual fertilizer from the previous crops, and equipment are not fully utilized by the majority of the local farmers. The planting of a second

crop could possibly utilize available resources during this period of time. Grains like corn (Zea mays L.) and grain sorghum (Sorghum bicolor (L.) Moench) are good second crop alternatives, because Florida is a net grain importer and the climate and soil are suitable for these crops.

Several experiments dealing with the main problems observed in the Hastings area (soil fertility, bed and plant population management, and cultivar evaluations) were conducted during 1977 and 1978, both in farmers' fields and at the Agricultural Research Center (ARC) at Hastings, Florida. The main objective of the research was to determine management needed for growing corn and grain sorghum after the cabbage and potato harvest.

LITERATURE REVIEW

General

Multiple Cropping

The recent emphasis on multiple cropping as a useful tool in food production, could probably be attributed to Bradfield(6, 7). His work has spread to Asia, Africa, the USA, and Latin America. The advantages and possibilities of multiple cropping systems (intercropping, relay cropping, succession cropping, etc.) are well known and have been practiced for generations by subsistence farmers. Extensive reviews and detailed research reports on modern multiple cropping studies are abundant in the literature (13, 26, 45, 52), and therefore will not be considered here.

Corn or Sorghum Following Vegetables

In order to sustain its cattle industry, Florida must import grain. The area planted to corn in Florida was 204,120 ha and the total production was 769,745 metric tons (12) in 1977. Gallaher[1/] has estimated that an additional 162,000 and 24,300 ha could be double cropped with corn and sorghum respectively by 1985.

As early as 1959, Kretschmer and Hayslip (32) recognized the advantages of growing field corn following tomatoes and other highly

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1/ Gallaher, R. N. 1976. Potential for Multiple Cropping Growth. Mimeo report 9/1/76. Agronomy Department. University of Florida. 3 p.

fertilized vegetables in south Florida. The authors pointed out that no P, K, or micronutrients need to be applied to the corn crop. In a later report Kretschmer, Hayslip, and Forsee (33) proposed that both corn and sorghum were good alternatives to follow winter vegetables and suggested that cattlemen who lease ranch land to tomato growers each year, can reap additional benefits by planting a grain or silage "catch" crop between fall tomatoes and summer pastures. In this way within 12 months the same field can produce tomatoes, field corn, and good quality pasture.

Soybean (Glycine max. L.) peanut (Arachis hypogaea L.), and southern pea (Vigna unguiculata (L.) Walp) were grown successfully as relay cropping after an initial crop of corn or sorghum in Florida (20). In this study it was concluded that irrigation would be indispensable for this particular cropping system. Akhanda et al. (2) also studied relay intercropping systems. Peanut, soybean, pigeonpea (Cajanus cajan (L.) Druce), and sweepotato (Ipomoea batatas (L.) Lam) were interplanted in middles between rows of early, medium and late-maturity hybrid corn for two years. Interplanted crops did not affect corn grain yield in either year. Control of weeds and ease of harvest were more difficult than in sole planting, so the authors recommended double cropping where the growing season is long enough for successive cropping.

Hipp and Gerard (25) indicated that in the lower Rio Grande Valley of Texas and northeastern Mexico two or more cash crops may be grown on the same location per year. They worked successfully with grain sorghum and cotton planted immediately after cabbage.

In Georgia, Gallaher (14) explored possibilities of triple cropping systems in which sweet and field corn as well as grain sorghum were

interplanted in winter barley before it was mature. Third crops after corn and sorghum included, among others snapbean (Phaseolus vulgaris L.), and English pea (Pisum sativum L.). However, the most impressive system was one of barley followed by relay field corn and by a crop of soybean planted by the first week of July.

Soil and Leaf Analyses

The possibilities, advantages, and limitations of soil and plant analyses as tools for studying and predicting crop response are topics widely found in the literature. Different methods have been used in order to obtain meaningful correlations between soil and plant analyses values and crop responses. The most popular approach has been the critical level or the concentration of an element below which the crop yield or performance is decreased below optimum (62). Jones and Eck have criticized this method on the basis that it designates only the lower end of the analysis spectrum. Instead they have proposed the use of sufficiency ranges, the optimum element concentration range below which deficiency occurs and above which toxicity or unbalances occur (29, 30). This system of plant evaluation is in use in the University of Georgia Plant Analysis Laboratory.

Plant growth and yields are functions of many variables beyond the single nutrient under consideration. Sanchez (52) quoting an earlier work by Fitts, points out that actual yields are functions of over a hundred variables, which can be grouped into soil, crop, climate, and management categories. The same author affirms that soil test correlations cannot predict yields or even absolute yield responses because of the many

variables involved. However, he considers that a major breakthrough in soil test correlations occurred with the development of the Cate-Nelson method. This is a graphic method which consists of plotting relative yields (percents of maximum) as a function of soil test values under a plastic overlay sheet divided into quadrants. The quadrants separate critical levels and soil with high and low response to nutrients.

The "nutrient intensity and balance" is a soil testing procedure, developed by Geraldson (18), that measures the ionic equilibrium in the soil solution. The electrical conductivity of the saturation extract is used as an indicator of nutrient concentrations or intensity which can range from deficient to optimum to excessive for crop production. Specific cations or anions contained in the saturation extract are calculated as percent of the total salt concentration and used as an indicator of nutrient balance. From 1955 to 1963 recommendations to establish a more favorable nutrient intensity and balance were associated with a 50% increase in tomato yield in Florida (18).

Probably the latest approach to foliar analysis is the Diagnosis and Recommendation Integrated System (DRIS). According to Summer (57), the critical value and the sufficiency range methods are not able to deal adequately with the variation in nutrient concentration on a dry matter basis with age. The DRIS method, on the contrary, overcomes this difficulty because it is an holistic approach in which as many yield determining factors as are capable of quantitative or qualitative expression are considered simultaneously in making diagnosis. The yield-determining factors are characterized in terms of indices which are derived as comparable functions of yield.

Most authors agree, independently of the methods used, that plant and soil analysis are definitely valuable tools and that their use should be extended. Engelstad and Parks (11) consider soil and tissue testing as being more important in the present age than ever before. The authors emphasize that these are the only ways in which soil fertility levels can be monitored and application practices adjusted, and finally state that the credibility of soil and plant testing must be maintained and protected.

Fertility of Corn and Sorghum

Fertility evaluations of corn and sorghum grown as monocrops have received considerable attention from agronomists (27, 28). An example of critical values for corn and nutrient sufficiency ranges for both corn (30) and sorghum (36), derived from many research studies, are presented in Table 1.

However, when double cropping is involved, and if the previous crop is a well fertilized vegetable crop, the situation could be drastically different. The buil-up of P and K in soils is a relevant topic in this time of energy shortage. Engelstad and Parks (11) suggest a reevaluation of fertilization programs to make certain they mesh with soil fertility levels and crop needs. It is estimated that the recovery of applied P by crops during the year is between 5 and 20% and for K the value is from 30 to 60%. This leaves substantial quantities of fertilizer P and K in the soil (significant leaching losses occur only in sandy soils of low cation exchange capacity). The same authors quoting a 1940 report by Terman and Wyman point out that an estimate of 20% N, 30% P, and 35% K applied remained in the soil after removal of a potato crop.

Table 1. Critical values for corn and sufficiency ranges for corn and sorghum

Element	Critical values for corn Jones (30) Ear leaf [1]	Nutrient sufficiency ranges Lockman (36) Corn, ear leaf [2]	Sorghum 3rd leaf [3]	Corn grain Jones (30) at maturity	Sorghum grain at maturity [4]
	%				
N	3.00	2.76-3.50	3.3 -4.0	1.0 -2.5	2.02
P	0.25	0.25-0.40	0.20-0.35	0.2 -0.06	0.42
K	1.90	1.71-2.50	1.4 -1.7	0.2 -0.4	0.37
Ca	0.40	0.21-1.00	0.30-0.60	0.01-0.02	0.012
Mg	0.25	0.21-0.60	0.2 -0.5	0.09-0.20	0.17
	ppm				
Mn	15	20-150	8-190	5-15	23
Fe	15	21-250	65-100	30-50	45
Zn	15	20-70	15-30	-	200
B	15	20-70	15-30	1-10	-
Cu	5	6-20	2-7	1-5	13
Al	-	200	0-220	-	-

1/ at tassel
2/ at silk
3/ below head at bloom stage
4/ determined by Agronomy Research Support Laboratory and Analytical Research Laboratory of the Soil Science Department, University of Florida.

Engelstad and Parks (11) quoting a study by Cummings reported that North Carolina farmers in 1943 added to the soil by fertilization about 60% as much N, 430% as much P, and 158% as much K as was removed by the potato crop. In 1957 Terman (58) emphasized the increasing difficulty in finding sites sufficiently responsive to P to permit a meaningful comparison of P sources. Another possible cause of P and K accumulation is the habitual application of certain grades at the same rate over time, without regard for fertility levels. While some of this repeated application of certain ratios may reflect farmer reluctance to change, farmers simply may not have alternative choices in some states (11). Very recently McCollum (38) reported significant increases in total and extractable soil-P reserves when high rates of P were applied to potatoes over many years. While fertilization practices for other crops grown in rotation with potato reflect both plant demand and soil-test P, many producers continue to fertilize potatoes with little regard to crop requirements nor to existing soil P levels. If neither potato nor crops grown in rotation with them require such high rates of directly applied P, a considerable saving in fertilizer costs could be realized (11).

Large initial applications of P to high-P-fixing soils had a marked residual effect on maize yields 7 to 9 years after applications (31). Even when P was added in the row, maize yields were 50% higher where high rates had been applied 9 years before. No further increase in maize yields, reports Kamprath (31), was obtained when available soil P (0.05 $\underline{N}$ HCl + 0.025 $\underline{N}$ H_2SO_4 extractant) was > 8 ppm. A field study conducted by Powell (47) in Iowa showed that corn yields responded largely to applied N, with applied P and K having smaller and less consistent effects. Maximum

yields were obtained with the first or second increment of applied N, P, and K in all years. Higher fertilizer rates had little additional effect on yields the first 2 years but caused some decrease the third year. Cope (8) showed negative response of corn yield to high amounts of P applied during an 11-year period. Rates used were 22.4, 44.8, and 67.8 kg P per ha.

In a Malaysian Tropofluvent, Lim, and Shen (35) found that corn grain yield responded significantly to 100 kg/ha P and continued to provide enough P through the sixth corn crop. Grain yield, available P, and leaf P concentration relationships showed critical available soil test P at 25 ppm and P concentrations of the leaf at 0.27%.

The influence of the previous crop and N application on yield of sorghum was studied by Hipp and Gerard (25). There was a sharp increase in grain sorghum yield with 67 kg/ha of N if sorghum followed cabbage, but application of the same rate of N to grain sorghum grown on soil that had been fallow from August until March did not significantly influence grain sorghum yields. Increasing N rates to 134 kg/ha resulted in only a slight additional increase in yield. Apparently fall and winter temperatures are warm enough that N mineralization allows accumulation of NO_3-N in the soil profile and may preclude a response from application of N.

Double cropping corn or sorghum planted after other cereals are also popular cropping systems in the United States. The resulting nutrient relationships are found in several reports. Murdock and Wells (40) investigated yields, nutrient removal, and nutrient concentrations when corn was planted after barley (Hordeum vulgare L.) and oat (Avena sativa L.). Corn grown after barley, harvested in soft dough averaged 25% more yield than

that grown after oat, harvested at heading. Fertility rates above 280-89-232 kg/ha of N-P-K did not significantly increase the yield. The average nutrient removal at the foregoing rate of fertility was 241-54-260 kg/ha of N-P-K. One fact in this study was that the small grain accounted for 47% of the total K removed. Nelson et al. (43) planted corn and grain sorghum with or without tillage following winter wheat (Triticum aestivum L.) or barley. Yields did not differ significantly for conventional tillage and no tillage plantings made on the same date. An application of 28 kg P and 168 kg K per ha each fall was sufficient to meet the needs of P and K for both crops. Nitrogen was supplied to either corn or sorghum at a rate of 224 kg/ha when the plants were 25 to 35 cm tall. In Georgia, Gallaher and Nelson (15) studied the soil fertility management of several double cropping systems. Wheat and barley were used as winter crops followed by soybean, corn, or grain sorghum. Results showed that effective fertilization should include lime, P, and K in the fall with incorporation to satisfy needs of both winter and summer crops. The authors also found that systems having small grain forage followed by the summer crops tended to reduce the soil pH, P, and K levels more than systems having small grain for grain. In general the double cropping systems were fertilized with less N and about equal or slightly more P and K than the sum of what would be recommended for the winter and summer crops if grown separately as monocrops. This last concept reflects an important aspect of a cropping system, the components are not additive but instead form a new unit with definable characteristics.

Drainage and Irrigation Beds

It is estimated that 90% of the world's farming area receives too little rain during the growing season. Of the other 10% some places get too much rain. Almost nowhere is rainfall ideal (55).

In the Hastings area, annual rain of nearly 1,270 mm has a pattern that is not sufficient for the potato and cabbage crops. The reason is that half of the year's rain falls in June, July, and August (55), while potato and cabbage are grown from December to May. Local farmers have traditionally used a system of bedding and water furrows for drainage and irrigation. Each water furrow is slightly deeper than the alley between row beds which are crosscut to allow surface water to move to the water furrow. Drop pipes at the ends of the water furrow convey run off water to boundary ditches (49). Under this system irrigation water is supplied during dry periods to the water furrows to maintain the water table at 12 to 25 cm below the alley height at the midpoint between water furrows (22). In 1973 corrugated plastic tile drains were installed on the ARC on a trial basis. The drain tiles were used both for irrigation and drainage. One end of the tile was raised to ground surface to facilitate irrigation and the other end discharged into an open ditch. Reports by Rogers, Hensel, and Campbell (49) and Hensel (23) showed the advantages of this system. Potato yield increased by 56% (12% of this increase was due to increase in number of rows, since water furrows were eliminated, the number of beds increased from 16 to 18), plants emerged about one week earlier over the drains, there was an improvement on water control, there were no water furrows to maintain, and potentially less water was used. A later report by Hensel (24) points out other important

aspects of the tile drainage system: 1) yield increases up to 50% can be achieved during wet seasons; 2) the tile systems removed internal soil water in 12 hours as compared to 2 1/2 days by a conventional system; 3) planting or harvesting operations could be performed satisfactorily soon after a rain on tiled land.

In a report by Bishop et al. (4) the authors reviewed several aspects that have been related to the shape of the potato soil bed, like incidence of greening of potato tubers, differences in tuber-set and yield, soil temperature, drainage and infiltration of water, equipment design for application of chemicals, and cultivation and harvesting of the crops. The authors developed a profilometer to measure changes occurring in the potato soil bed profile during growth of a potato crop. Changes in bed cross sectional area were found to be closely related to changes in soil bulk density and air permeability on the Hesperia sandy loam from California.

Allen and Musick (3) tested a wide bed-furrow system for irrigation of winter wheat and grain sorghum on a slowly permeable clay loam in the Southern High Plains (Texas). The system consisted of 152 cm spaced furrows separating relatively broad flat beds about 100 cm wide compared with conventional 100 cm bed furrows where wheel traffic occurs in irrigation furrows. Yields were not different. Water intake during irrigation of wide bed-furrows averaged 23% less during three spring irrigations, and 19% less during two seasonal irrigations of grain sorghum. In an earlier study, Musick and Dusek (41) reported a 15% yield increase when growing grain sorghum and winter wheat in alternating 203 cm field beds with adequate irrigation. The increased yields on strip-planting plots

was believed to be associated with increased light interception, although increased soil water availability may have been a factor also.

In Arkansas, growing cotton in narrow rows on permanent wide beds is a very common procedure. However, it is understood from the beginning that a farmer could not be expected to adopt permanent wide beds for his cotton acreage unless the same cultural system could be used for his other crops. Parish and Mermond (46) reported successful crops of soybeans, grain sorghum, and corn planted in the wide beds. There was no loss of yield; indeed, yield was increased in some years.

Good results were also obtained by Nolte (44) in Ohio. Corn yield planted in beds was 4778, 6048, and 6411 kg/ha when the drainage system was by surface only, tile only, and surface + tile respectively.

The effect of mulches and bed configuration was studied by Adams (1) in Texas during 2 years. Bed configuration had a significant effect on sorghum growth when used with mulches and caused a significant increase in grain sorghum during the first year but not during the second.

Cultivar Experiments

Cultivar experiments are one of the most popular and useful research tool available to agronomists. The Agricultural Experiment Stations in Florida do cultivar evaluations on a continuous basis for all major crops planted in the state. The Florida Field and Forage Crop Variety Report (64) is published for reference use only, while Agronomy Facts (65) sheets provide specific recommendations for use of cultivars. In the case of corn, the hybrids recommended have been evaluated in station trials for at least two years. In addition to yield, standability, ear

quality, husk cover, ear height, and insect resistance are also evaluated. Sorghum trials include yield performance, bird resistance, plant height, and number of days to bloom. Sorghum and field corn production guides (27, 28) are also published and include cultivar suggestions. Cultivar experiments are also conducted for specific purposes. Green (19) gave a detailed report on yield and digestibility of 41 grain-sorghum bird-resistant and non-bird-resistant hybrids.

Comparative trials using both corn and sorghum varieties were reported by Dunavin (10) and Lutrick (37). Sometimes sorghum outyields corn and vice-versa depending on conditions and purposes of the studies.

MATERIALS AND METHODS

The area near Hastings, Florida (29° 43' N 81° 30' W) includes farm land in St. Johns, Flagler, and Putnam counties. Most of this land is about 3.0 m above sea level and from 16 to 32 km from the coast. The annual rainfall is nearly 1,250 mm and usually half of this amount falls during the summer months.

This area normally produce an estimated 9,300 ha of potato and 5,300 ha of cabbage. This full area is potentially suitable for growing corn and grain sorghum in double cropping systems. Potato is grown from January to May. Cabbage is grown over a much wider season; however, most of the cabbage crop is produced for harvest in March.

Three different types of experiments were conducted: fertility, bedding, and cultivar experiments as described below.

Fertility Experiments

Two corn and three sorghum fertility experiments were planted in 1977; one corn and one sorghum fertility experiment was planted in 1978. Location, planting and harvest dates, hybrid used, row spacing, number of replications, and type of drainage are given in Table 2 for each of the studies. In all locations experiments were planted in Rutlege fine sand (Sandy, Siliceous, Thermic family of the Typic Humaquepts) which had previously been either in cabbage (the corn experiments) or in potato (the sorghum experiments) production.

Table 2. Basic information for all experiments during 1977 and 1978

Experiment No.	Location	Planting date	Harvest date	Brand hybrid	Row spacing cm	No.of reps.	Drainage
			1977				
1 Corn fertility	Dick Reid farm	3/11	7/18	Wilstar 9990	100	5	tile
2 Corn fertility	Roger DuPont farm	3/11	8/16	McNair-508	100	5	ditch *
3 Sorghum fertility	Dick Reid farm	7/6	10/25	Dekalb E-59	100	5	tile
4 Sorghum fertility	Dick Reid farm	6/21	9/14	Wilstar 1225	100	5	ditch *
5 Sorghum fertility	ARC	7/27	11/4	Dekalb E-59	100	4	tile
6 Bedding	ARC	7/5	10/7	Dekalb BR-54	Variable	4	tile
7 Cultivar	ARC	7/7	10/18	8 hybrids	100	4	tile
			1978				
8 Corn fertility	Jimmy Freeman farm	3/8	7/18	Pioneer 14	100	5	ditch *
9 Sorghum fertility	ARC	6/20	9/18	Dekalb BR-54	100	4	tile
10 Bedding	ARC	6/19	9/18	Dekalb BR-54	Variable	4	tile
11 Cultivar	ARC	6/22	9/18	8 hybrids	100	4	tile

* sub furrow

A 4 x 2^2 factorial in a randomized complete block design was used in all fertility studies, with 4 replications at the ARC and 5 replications in farmer's fields. Four N rates (0, 100, 200, and 300 kg/ha), 2 P rates (0, 60 kg/ha), and 2 K rates (0, 60 kg/ha) were used in all combinations. Plots (10 m x 5 m) had 6 rows in all cases but only the 4 middle ones were used to collect samples or to determine yield.

The land was listed and disk harrowed before the 1 m drainage beds were built using a conventional "bedder." Planting was done with a double hopper tractor. Fertilizer was applied by hand on top of each row. Nitrogen was applied in two equal amounts, at planting and 4 weeks later, P and K were applied all at planting time.

Farmers performed normal cultural practices like bed formation, planting, and cultivation; however, weed control and irrigation were not satisfactory during 1977 and affected crop yield potential. At the ARC all operations were better controlled and monitored by field personnel.

Insect pests were particularly serious in 1977; this made it necessary to replant experiments No. 3 and 5, and prompted the application of insecticides. A list of pesticides used during both years is presented in Table 3.

In all fertility studies soil samples were taken from each replication before planting and from each experimental plot before harvesting. Ten cores were collected from a depth of 0 to 18 cm, the samples were air dried, and passed through a 2 mm stainless steel sieve. Soil extraction was done by means of the double acid procedure or North Carolina extract (51). Five grams of soil were weighed and extracted with 20 ml of

Table 3. Pesticides used and dates applied during 1977 and 1978

Pesticide 2/	Experiment No. 1/ 3	4	5	6	7	8	9	10	11
	1977						1978		
Paraquat (a)	7/5								
Paraphos (b)	7/27								
Methamidophos (c)		7/7					7/11	7/11	7/11
Methomyl (d)		7/28			7/21				
Carbaryl (e)			9/22	9/21	9/22				
Atrazine (f)+ propachlor (g)							6/20	6/19	6/22
Carbofuran (h)			7/27	7/7	7/5	3/8	6/20	6/20	6/20
Evik (i)+ 2, 4D (j)						5/25			

1/ Experiments No.1 and 2 did not have pesticide application.
2/ Rates were used according to the label.
(a) 1, 1'-Dimethyl-4, 4'-by pyridinium ion (post directed)
(b) 0, 0-Diethyl O-p nitrophenyl phosphorothioate
(c) 0, S-Dimethyl phosphoramidothionate
(d) S-Methil-N-((methylcarbamoyl)oxy)thioacetimidate
(e) 1-Naphthyl N-methylcarbamate
(f) 2-Chloro-4-ethylamino-6-isopropylamino-s-triazine (at planting)
(g) 2-Chloro-N-isopropylacetanilide (at planting)
(h) 2, 3-Dihydro-2,2-dimethyl-7-benzofuranyl-methylcarbamate (at planting)
(i) 2-(ethylamino)-4-isopropyl amino-6-methylthio-s-triazine(post directed)
(j) 2,4-Dichlorophenoxyacetic acid. (post directed)

0.05 N HCl + 0.025 N H_2SO_4 for five minutes in an Eberbach mechanical reciprocating shaker (160 oscillations/minute). The extracts were filtered through Whatman No. 6 filter paper and stored in 25-ml vials under refrigeration until analyzed for P, K, Ca, Mg, Cu, Zn, Mn, and Fe. Phosphorus was determined colorimetrically using a Technicon Auto Analyzer. Potassium was determined by flame emission photometry and the rest of the elements were determined by atomic absorption spectrophotometry.

Soil pH was measured for each sample using a Corning glass electrode potentiometer and a 1:2 soil to water ratio. The 50 ml mixture was stirred, left standing for one half hour, and stirred again prior to reading (51).

Corn leaf samples were collected during the early silk stage, the complete earleaf was taken from the lowest ear on 10 plants per plot. The same procedure was followed in the sorghum experiments with the difference being the type of leaf collected, in this case 10 to 15 leaves were taken per plot, usually corresponding to the third leaf from the top. Forage samples were taken at harvest from each plot during 1978. Two 8 m long rows of corn or sorghum were cut at the base and the total fresh weight recorded. A smaller sample, 4 or 5 plants, was also weighed in the field, then dried in forced-air forage dryers at 65° C for a minimum of 48 hours, and then weighed again in order to determine dry matter content in each plot.

Leaf samples were ground (pulverized) in a Cristy Norris Mill to less than 1 mm particle size, then mixed thoroughly after grinding and kept in airtight sample bags. Forage samples were chopped in a mulching machine, 'Mighty Mac' (Amerind MacKissic), and subsampled before they could be ground in the mill.

Nitrogen analyses were done following accepted procedures described by Gallaher (16). A 100 mg sample of the ground plant tissue was placed into a 75 mm pyrex test tube along with 3.4 g of prepared catalyst (90% anhydrous K_2SO_4 + 10% anhydrous $CuSO_4$), two or three Alundum boiling chips, and 10 ml of concentrated H_2SO_4. The contents were mixed and a total of 2 ml of 30% H_2O_2 was added immediately in 1 ml increments. Small funnels were placed on top to recondense liquids into the test tube. Samples were digested at 385° C in a 126 sample capacity aluminum block (17). After cooling, samples were stirred in an automatic mixer and the solution was then diluted to 75 ml with distilled water and analyzed with a Technicon Auto Analyzer.

Phosphorus, K, Ca, Mg, Cu, Zn, Mn, and Fe were analyzed by routine methods (63). One gram of plant sample was placed into a 50 ml pyrex beaker and ashed at 480° C for a minimum of 6 hours. A small amount of distilled water and 2 ml of concentrated HCl were added to the ash and this mixture was gently heated on a hotplate until dry. Following this, another 2 ml of concentrated HCl were added with about 15 ml of distilled water. This mixture was covered with a watchglass and digested for one-half hour before being diluted to 100 ml and stored in a plastic vial. The stored digestate was approximately .1 N HCl. Phosphorus was determined colorimetrically, K by flame emission photometry, and Ca, Mg, Cu, Zn, Mn, and Fe by atomic absorption spectrophotometry.

The revised two-state in vitro organic matter digestion (IVOMD) procedure was done on all forage samples (39). The technique involves a 48 hour fermentation by rumen microorganisms followed by a HCl-pepsin digestion. Separate aliquots were analyzed for organic matter content in the sample and for residual organic matter after the fermentation-digestion.

The amount of organic matter disappearing was considered to have been "digested."

The statistical analysis included an analysis of variance for all responses, analysis at different levels of one factor when significance was found, Duncan's multiple range tests to compare means, and correlations between nutrient concentration and content in the soil and in the plant. The statistical model was:

$$Yijk\ell = \mu y + \rho\ell + \alpha i + \beta j + \partial k + (\alpha\beta)ij + (\beta y)jk + (\alpha\partial)ik + (\alpha\beta\partial)ijk + \varepsilon ijk\ell$$

where $Yijk\ell$ = response

$\rho\ell$ = ℓ^{th} block effect
αi = i^{th} nitrogen effect
βj = j^{th} phosphorus effect
∂k = k^{th} potassium effect
$(\alpha\beta)ij$ = ij nitrogen-phosphorus interaction effect
$(\alpha\partial)ik$ = ik nitrogen-potassium interaction effect
$(\alpha\beta\partial)ijk$ = ijk nitrogen-phosphorus-potassium interaction effect
$\varepsilon ijk\ell$ = error term

Bedding Experiments

Initial observations indicated that the use of the 1.0 m previous potato beds caused an apparent waste of space and yield reduction for the sorghum crops. To test this hypothesis two bedding experiments, one in 1977 and one in 1978, were designed and conducted at the ARC. The 1.0 m beds were modified and 1.5 m and 2.0 m beds were built and a total of 16 treatments were imposed on them (Table 4).

Land was prepared in strips to facilitate the use of machinery. Each one of the four replications had a strip of land that included the 3 bed widths and thus the 16 treatments. Building the 2.0 m beds was relatively easy and it was accomplished by removing every other 1.0 m

Table 4. Treatments imposed on the bedding experiments, 1977 and 1978.

Treatment No.	Bed width (m)	Arrangement
1	1.0	One row (control)
2	1.0	Double row narrow (15 cm)
3	1.0	Double row wide (25 cm)
4	1.0	Broadcast
5	1.0	Single row in flattened bed
6	1.0	Double row in flattened bed (25 cm)
7	1.0	Broadcast in flattened bed
8	1.5	Three rows
9	1.5	Four rows
10	1.5	Five rows
11	1.5	Broadcast
12	2.0	Three rows
13	2.0	Four rows
14	2.0	Five rows
15	2.0	Six rows
16	2.0	Broadcast

bedder. The 1.5 m beds required a narrower tractor with a wheel spacing. In order to plant 2 rows in the normal 1.0 m beds they had to be knocked down slightly on the top. Sorghum planters were offset 7.5 and 12.5 cm from the center of each bed and planted twice in order to achieve the 2 narrow and wide rows.

Soil samples were taken from each replication. They were prepared and analyzed in the same way as the samples of the soil fertility experiments. A total of 222 kg NH_4NO_3/ha was applied to all treatments 4 weeks after planting.

Specific information on planting and harvest dates, cultivar, drainage, herbicides, and insecticides used is presented in Tables 2 and 3. During 1977 handweeding was done on the 1.5 and 2.0 m beds; in 1978 weed control was satisfactorily accomplished by the use of herbicides (Table 3).

Whole plant samples were collected at harvest time and dry matter, IVOMD and nutrient analysis was done as previously described for the fertility experiments. Grain yield, plant height and plant population was also recorded and included in the statistical analysis. Due to a severe sorghum "midge" (Cantarinia sorghicola (Coquillet)) damage, an insect that affects grain formation, grain yield in 1977 was estimated by running a correlation between grainless heads weight and heads with grain from a healthy field of the same cultivar.

The experiment was a nested split-split-plot arrangement of treatments in a randomized complete block design with 4 blocks. Arrangements within beds were nested and correspond to the first split; years make the second split. The statistical model was:

$$Yijk\ell = \mu y + \rho\ell + \alpha i + \varepsilon a\ell i + \beta j(\alpha i) + \varepsilon b\ell j(i) + \partial k + \alpha\partial ik + \beta\partial jk(\alpha i) + \varepsilon c\ell k(m)$$

where Yijkl = response

$m = 1,\ldots, \sum_{i}^{1} \varepsilon_1 ji = 16 \quad j_1 = 7, \quad j_2 = 4, \quad j_3 = 5$

αi = i^{th} bed effect
$\beta j(\alpha i)$ = j^{th} arrangement within i^{th} bed effect
∂k = k^{th} year effect
$\varepsilon a\ell i$ = $(\rho\alpha)\ell i$
$\varepsilon b\ell j(i)$ = $(\rho\beta)\ell j(\alpha i)$
$\varepsilon c\ell k(m)$ = $\rho\partial\ell k((\beta\alpha)m)$

Cultivar Experiments

Considering the potential of the area not only as a grain but also as a forage producer, two cultivar experiments, one in 1977 and one in 1978, were conducted at the ARC. A list of the cultivars tested for both grain and forage, is shown in Table 5.

Cultivars were planted using a composite split-plot in a randomized complete block design with 4 replications, the split corresponds to years. Planting was done on the usual 1.0 m beds and treatments were fertilized with a total of 222 kg NH_4NO_3/ha 4 weeks after planting. Planting and harvest dates as well as drainage, herbicides, and insecticides used are shown in Tables 2 and 3. Soil samples were taken from each replication before planting and whole plant samples were collected at harvest time.

Grain yield (when applicable), and dry matter yield, were recorded for most varieties. A combined (2 year) statistical analysis as well as separate analysis per year was conducted using the following models:

$Yij\ell = \mu + \rho\ell + \alpha i + \varepsilon\alpha ai + \beta j + \alpha\beta ij + \varepsilon bj\ell(i)$; 2 years
$Yi = \mu_1 + \rho\ell_1 + \alpha_1 i + \varepsilon_1 i\ell$; 1 year

where $Yij\ell$ and Yi = responses

$\varepsilon ai\ell = \alpha\rho i\ell$
$\alpha bj\ell(i) = \beta\rho j\ell(\alpha i)$
αi = i^{th} variety effect, i=1,...,5
βj = j^{th} year effect, j = 1, 2

Table 5. Cultivars tested at Hastings during 1977 and 1978.

Number	Brand and hybrid 1977	Brand and hybrid 1978
1	Dekalb FS-25A	Dekalb FS-25A
2	Northrup King NK-121	Northrup King NK-121
3	Dekalb C-42Y	Dekalb C-42Y
4	Dekalb BR-54	Dekalb BR-54
5	Dekalb D-60	Dekalb D-60
6	Dekalb FS-24	Dekalb FS-24
7	Dekalb A-26	Dekalb A-26
8	Dekalb E-59	Grower ML-135

RESULTS AND DISCUSSION

Precipitation and temperature data for the area during 1977 and 1978 are shown in Table 6. There was a marked difference in precipitation, 1977 being considered a very dry year (58).

Fertility Experiments in 1977

Corn

Experiments No. 1 and No. 2 had low yields (Tables 11 and 12). This was the result of poor weed control and water management by farmer cooperators. Soil analysis data before planting showed low pH values, and high P and Ca concentrations which provided an insight on the natural fertility of these soils and the previous vegetable fertilizer practices (Tables 7, 8).

Significance of variables according to the F test and nutrient concentrations in the soil and leaves are presented in Tables 9 to 14. Increasing rates of N caused a drop in pH values. This was likely due to the release of hydrogen ions (H^+) when ammoniacal and most organic N fertilizers were converted to nitrates (65). Higher rates of N and P applied to the soil lowered the concentration of Ca in experiment No. 1 and increased that of Mn (Table 15). A K defficiency was observed in the leaves reflecting the low soil K test. The addition of K fertilizer increased significantly soil test K, but not K concentration in the leaves. Higher N rates also increased N and Cu concentration and decreased Mg concentration in the leaves. In experiment No. 2 the higher rate of K (60

Table 6. Temperature and precipitation data for 1977 and 1978. Hastings area, Florida (42)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
							1977[1/]						
Temp °C	9.0	12.3	20.3	21.1	24.3	28.8	28.8	28.0	27.6	21.0	18.7	14.1	
Precip mm	91.7	27.2	23.9	19.8	56.1	36.8	77.7	182.9	103.6	15.0	106.7	186.4	927.8
							1978[2/]						
Temp. °C	9.4	15.5	19.9	23.4	23.4	25.8	26.8	26.6	25.7	21.0	19.4	15.7	
Precip mm	86.9	98,8	92.7	46.5	68.1	136.4	256.3	234.9	90.2	18.8	1.3	120.9	1251.8

1/ Data from Palatka station, located about 12 km from experimental site
2/ Data collected from the ARC station

Table 7. Soil analysis before planting. Corn fertility experiment No.1, 1977

Rep	pH	P	K	Ca	Mg	Cu	Zn	Mn	Fe
		ppm							
I	5.3	416	76	1254	72	4.9	12.3	6.1	83
II	5.2	460	103	1406	92	5.9	9.3	6.9	88
III	5.2	484	159	2000	164	6.5	10.5	8.6	100
IV	5.3	498	113	1432	76	5.6	10.0	6.4	85
V	5.4	488	113	1334	100	5.3	9.6	6.2	94
$\bar{X}$		469	113	1485	101	5.6	10.3	6.8	90

Table 8. Soil analysis before planting. Corn fertility experiment No.2, 1977

Rep	pH	P	K	Ca	Mg	Cu	Zn	Mn	Fe
		ppm							
I	4.7	297	71	858	35	1.6	5.8	5.6	50
II	5.1	194	70	490	27	0.8	3.7	4.7	37
III	5.0	570	157	1678	148	2.4	8.8	9.4	69
IV	5.0	418	88	1176	73	2.0	7.3	6.7	60
V	5.4	238	124	642	40	1.0	4.2	4.9	58
$\bar{X}$		343	102	969	65	1.6	6.0	6.3	55

Table 9. Significant variables as determined by F test. Corn experiment No.1, 1977

Source	D.F	pH	N	P	K	Ca	Mg	Cu	Zn	Mn	Fe	Grain yield
		F-test on pH, soil nutrients concentration, and grain yield										
Rep	4											
TN	3	0.0001				0.0094						
TP	1											
TN x TP	3					0.0272				0.0065		
TK	1				0.0001							
TN x TK	3											
TP x TK												
TN x TP x TK	3											
		F-test on leaf nutrients concentration										
Rep	4											
TN	3		0.0001				0.0345	0.224				
TP	1											
TN x TP	3											
TK	1											
TN x TK	3											
TP x TK	1											
TN x TP x TK	3											

Table 10. Significant variables as determined by F test. Corn experiment No.2, 1977

Source	D.F	pH	N	P	K	Ca	Mg	Cu	Zn	Mn	Fe	Grain yield
F-test on pH, soil nutrients concentration, and grain yield												
Rep	4											
TN	3	0.0001			0.0030					0.0478		
TP	1											0.0316
TN x TP	3											
TK	1				0.0001							
TN x TK	3											
TP x TK	1											
TN x TP x TK	3											
F - test on leaf nutrients concentration												
Rep	4											
TN	3		0.0011	0.0002		0.0007	0.0007	0.0151		0.0001	0.0036	
TP	1			0.0111								
TN x TP	3				0.0359	0.0007						
TK	1					0.0004	0.0493					
TN x TK	3											
TP x TK	1											
Tn x TP x TK	3											

Table 11. Grain yield, pH, and nutrient concentration in the soil. Corn experiment No.1,1977

Treatment 1/			Grain yield		Nutrient concentration in the soil (ppm) at harvest							
N	P	K	(kg/ha)	pH	P	K	Ca	Mg	Cu	Zn	Mn	Fe
0	0	0	1314	5.02	547	103	1742	164	5.18	9.78	7.22	82.8
0	0	1	1560	5.04	546	157	1640	130	5.31	9.96	7.28	66.0
0	1	0	1272	5.04	546	87	1708	140	5.15	9.26	7.02	78.4
0	1	1	1382	5.06	617	150	1538	132	4.79	8.94	6.06	74.6
1	0	0	1834	5.00	558	89	1472	108	4.85	8.90	7.00	86.2
1	0	1	1149	5.08	553	111	1606	162	4.68	8.68	6.56	74.4
1	1	1	2012	4.92	576	99	1562	127	4.78	9.08	7.94	82.2
1	1	1	1697	4.94	567	156	1703	152	5.14	9.44	7.60	76.0
2	0	0	1464	4.90	610	104	1591	140	4.77	9.64	7.82	79.8
2	0	1	1395	4.88	584	114	1516	122	4.90	9.36	7.02	77.8
2	1	0	2134	4.90	582	105	1626	143	5.04	9.56	7.64	77.4
2	1	1	2163	4.88	558	131	1616	135	4.70	8.92	7.50	78.0
3	0	0	1930	4.70	561	113	1638	157	5.06	9.80	7.66	74.2
3	0	1	1656	4.96	604	138	1508	119	4.81	9.18	7.74	76.0
3	1	0	1834	4.70	562	96	1422	93	4.62	9.04	7.18	75.6
3	1	1	1820	4.80	562	130	1431	110	4.64	8.70	7.30	90.8

1/ N 0, 1, 2, 3 = 0, 100, 200, 300 kg N/ha
P 0, 1 = 0, 60 kg P/ha
K 0, 1 = 0. 60 kg K/ha
Values are an average of 5 replications

Table 12. Grain yield, pH, and nutrient concentration in the soil. Corn experiment No.2,1977

Treatment 1/			Grain yield		Nutrient concentration in the soil (ppm) at harvest							
N	P	K	(kg/ha)	pH	P	K	Ca	Mg	Cu	Zn	Mn	Fe
0	0	0	786	5.12	325	42	916	55	1.40	4.88	5.54	52.8
0	0	1	1351	5.14	316	78	773	42	1.05	4.02	5.02	44.6
0	1	0	818	5.08	397	47	1056	52	1.57	5.60	6.02	51.6
0	1	1	2004	5.06	351	75	866	47	1.19	4.40	5.36	51.0
1	0	0	1152	4.98	348	51	915	53	1.29	4.92	5.72	49.4
1	0	1	675	5.02	372	56	914	52	1.48	4.88	5.64	52.0
1	1	0	1483	4.92	334	48	852	57	1.12	4.54	5.72	47.6
1	1	1	1018	4.86	338	74	976	54	1.18	5.32	6.38	50.2
2	0	0	1715	4.80	321	57	949	57	1.36	5.18	6.34	51.2
2	0	1	1055	4.82	354	77	942	57	1.30	4.98	6.10	50.4
2	1	0	1520	4.86	376	57	922	47	1.20	4.84	6.36	50.4
2	1	1	1309	4.78	317	90	856	57	1.19	4.42	6.12	46.0
3	0	0	434	4.78	332	60	850	44	1.19	4.70	5.98	50.4
3	0	1	721	4.66	322	94	751	40	0.96	3.72	5.38	45.8
3	1	0	2140	4.76	355	52	810	42	0.99	4.02	5.84	43.2
3	1	1	1363	4.68	352	108	857	50	1.21	4.68	6.26	50.0

1/ N 0, 1, 2, 3 = 0, 100, 200, 300 kg N/ha
P 0, 1 = 0, 60 kg P/ha
K 0, 1 = 0, 60 kg K/ha
Values are an average of 5 replications

Table 13. Nutrients concentration in the leaves. Corn experiment No.1, 1977

Treatment			Nutrient concentration in the leaves at silk								
N	P	K	N	P	K	Ca	Mg	Cu	Zn	Mn	Fe
			%					ppm			
0	0	0	1.49	0.38	2.44	1.03	0.72	11.6	490	242	122
0	0	1	1.56	0.40	2.43	0.85	0.49	12.2	390	240	98
0	1	0	1.53	0.41	2.17	0.88	0.53	9.4	386	202	100
0	1	1	1.56	0.38	2.52	0.92	0.59	11.4	444	208	134
1	0	0	1.94	0.43	2.26	0.87	0.39	11.6	420	202	112
1	0	1	1.88	0.41	2.27	0.92	0.52	11.2	454	175	120
1	1	0	1.89	0.38	2.13	0.99	0.49	13.2	460	218	130
1	1	1	1.93	0.43	2.47	0.85	0.44	12.0	558	228	110
2	0	0	1.99	0.42	2.32	0.98	0.45	12.4	482	210	126
2	0	1	2.05	0.43	2.33	0.87	0.43	11.6	450	196	126
2	1	0	1.96	0.39	2.16	0.92	0.46	13.2	482	216	120
2	1	1	2.06	0.40	2.14	1.03	0.72	12.4	502	252	122
3	0	0	2.17	0.45	2.16	0.98	0.47	12.8	520	242	124
3	0	1	1.97	0.40	2.68	1.17	0.52	14.4	536	258	148
3	1	0	2.07	0.40	2.46	1.17	0.43	14.6	544	294	146
3	1	1	2.10	0.48	2.28	0.95	0.38	14.6	540	274	126

1/ N 0, 1, 2, 3 = 0, 100, 200, 300 kg N/ha
P 0, 1 = 0, 60 kg P/ha
K 0, 1 = 0, 60 kg K/ha
Values are an average of 5 replications

Table 14. Nutrient concentration in the leaves. Corn experiment No.2, 1977

Treatment 1/			Nutrient concentration in the leaves at silk								
N	P	K	N	P	K	Ca	Mg	Cu	Zn	Mn	Fe
			%					ppm			
0	0	0	2.05	0.35	2.18	0.36	0.17	17.8	570	77	78
0	0	1	1.96	0.33	2.50	0.31	0.14	18.6	550	64	90
0	1	0	1.90	0.36	2.10	0.39	0.21	15.6	542	86	78
0	1	1	2.16	0.33	2.26	0.38	0.17	16.0	554	84	90
1	0	0	2.34	0.32	2.20	0.42	0.19	17.4	572	89	92
1	0	1	2.56	0.33	2.18	0.38	0.18	15.2	552	101	90
1	1	0	2.62	0.36	2.34	0.37	0.15	16.4	568	98	112
1	1	1	2.59	0.38	2.12	0.32	0.16	15.2	530	96	90
2	0	0	2.77	0.37	2.26	0.41	0.16	20.8	524	105	102
2	0	1	2.73	0.36	2.24	0.40	0.15	20.4	558	106	100
2	1	0	2.75	0.40	2.30	0.42	0.16	20.2	570	110	102
2	1	1	2.83	0.37	2.30	0.38	0.13	18.8	558	111	100
3	0	0	2.99	0.42	2.20	0.43	0.15	19.0	464	128	104
3	0	1	2.93	0.36	2.38	0.38	0.13	18.4	574	116	124
3	1	0	2.81	0.41	2.32	0.40	0.12	18.8	554	120	110
3	1	1	2.91	0.42	2.26	0.40	0.13	19.0	556	107	112

1/ N 0, 1, 2, 3 = 0, 100, 200, 300 kg N/ha
P 0, 1 = 0, 60 kg P/ha
K 0, 1 = 0, 60 kg K/ha
Values are an average of 5 replications

Table 15. Effect of N and K on concentration of Ca and Mn in the soil at 2 levels of P. Corn experiment No.1, 1977.

N kg/ha	Ca		Mn	
	P = 0 ------ kg/ha	P = 60 --------	P = 0 ------ kg/ha	P = 60 --------
	---------- ppm ----------			
0	1691 a	1623 a	7.25 ab	6.54 b
100	1539 b	1633 a	6.78 b	7.77 a
200	1553 ab	1621 a	7.42 ab	7.57 a
300	1573 ab	1427 b	7.70 a	7.24 ab
K				
0	1611 a	1580 a	7.42 a	7.44 a
60	1568 a	1572 a	7.15 a	7.11 a

Means within each column for N or K treatments followed by different letters are significantly different according to Duncan's multiple range test.

(60 kg/ha) increased the K concentration in the leaves at 0 level of N but not at the 100, 200 or 300 kg/ha levels (Table 16). However, K concentration in the soil decreased when going from 0 to 300 kg N/ha. Higher N rates increased N, P, Cu, Mn and Fe concentration in the leaves, however an opposite effect was observed for Mg concentration (Table 17). The 60 Kg/ K/ha rate caused a decrease in Mg concentration in the leaves accentuating the Mg deficiency observed in this experiment. Possibly most of these changes could be attributed to changes in balance of nutrients, since it has been shown that plants under uniform environmental conditions tend to take in a constant number of cations and anions (62).

Correlation coefficients for soil test and leaf nutrient concentrations were not consistent for the corn experiments in 1977. In experiment No. 1 (Table 18) Mg and Mn in the soil were positively correlated with Mg and Mn in the leaves, the R values were 0.32 and 0.37 respectively. Manganese in the soil was also positively correlated to the concentration of Ca in the leaves. However, the R value of 0.23 was also very low. In experiment No. 2 Mg in the leaves could be a good predictor of P, Ca, Mg, Cu, Zn, Mn, and Fe in the soil, positive correlations and R values ranging from 0.48 to 0.68 are presented in Table 19. Some of these results differ from those of Dingus and Keefer (9) who found that Mg, Mn, and Cu accumulation in plants was reduced by the presence of Zn in the soil. Phosphorus in the leaves was also positively correlated with Cu, Zn, and Mn in the soil (Table 19). There is disagreement again with several authors (50, 53, 54, 56) who report Zn deficiencies being accentuated by P.

Sorghum

Sorghum experiments No. 3 and No. 4 were also located on Farmers fields and were planted on tile and ditch (subfurrow) drained land,

Table 16. Effect of P and K (kg/ha) at different levels of N (kg/ha) on concentration of K and Ca in the leaves. Corn experiment No.2, 1977

P	K				Ca			
	N = 0	N = 100	N = 200	N = 300	N = 0	N = 100	N = 200	N = 300
kg/ha	%							
0	2.34 a	2.19 a	2.25 a	2.29 a	0.34 b	0.41 a	0.40 a	0.41 a
60	2.18 a	2.23 a	2.30 a	2.29 a	0.39 a	0.35 b	0.41 a	0.40 a
K								
0	2.14 b	2.27 a	2.28 a	2.26 a	0.38 a	0.40 a	0.42 a	0.42 a
60	2.38 a	2.17 a	2.27 a	2.32 a	0.35 a	0.36 a	0.39 a	0.39 a

Means followed by different letters are significantly different according to Duncan's multiple range test. Comparisons should be made within columns between P and K rates.

Table 17. Effect of N levels on pH, K, and Mg soil test and in the concentration of N, P, Mg, Cu, Mn, and Fe in the leaves. Corn experiment No.2, 1977

N	soil			leaves					
	pH	K	Mn	N	P	Mg	Cu	Mn	Fe
kg/ha		ppm		%			ppm		
0	5.10 a	78.8 a	5.5 b	2.02 c	0.34 b	0.17 a	17 bc	78 c	84 c
100	4.94 b	71.0 ab	5.9 ab	2.53 b	0.35 b	0.17 a	16 c	96 b	96 bc
200	4.81 c	61.0 bc	6.2 a	2.77 a	0.38 a	0.15 b	20 a	108 a	101 ab
300	4.72 d	57.6 c	5.9 ab	2.91 a	0.40 a	0.13 b	18 ab	117 a	112 a

Means followed by different letters are significantly different according to Duncan's multiple range test. Comparisons should be made within columns.

Table 18. Correlation coefficients for soil and leaf nutrient concentrations. Corn experiment No.1, 1977

CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / N = 80

Leaf	Soil P	Soil K	Soil CA	Soil MG	Soil CU	Soil ZN	Soil MN	Soil FE
P	-0.04448 0.6952	0.03210 0.7774	-0.06935 0.5410	-0.16721 0.1382	0.16936 0.1331	0.00561 0.9606	0.13804 0.2221	-0.04102 0.7179
K	-0.01949 0.8638	0.19714 0.0796	-0.07120 0.5302	-0.07688 0.4979	-0.10061 0.3746	-0.01307 0.9084	-0.03322 0.7698	0.04538 0.6894
Ca	0.06222 0.5835	0.14324 0.2050	0.03522 0.7565	0.01072 0.9248	0.02590 0.8196	0.01479 0.8964	0.23080 0.0394	0.04413 0.6975
Mg	-0.08611 0.4476	-0.10990 0.3318	0.11164 0.3242	0.31607 0.0042	-0.18955 0.0922	-0.09492 0.4023	-0.15193 0.1785	-0.00114 0.9920
Cu	0.14920 0.1865	0.14554 0.1977	-0.09804 0.3869	-0.11795 0.2974	0.08796 0.4378	0.10934 0.3343	0.27103 0.0150	0.13045 0.2488
Zn	0.11048 0.2952	-0.04273 0.7066	-0.14847 0.1887	-0.14035 0.2143	0.14733 0.1922	0.09461 0.4038	0.12051 0.2870	0.15483 0.1703
Mn	0.21446 0.0561	0.36420 0.0009	0.08899 0.4325	-0.10337 0.3615	0.30544 0.0059	0.06016 0.5960	0.37625 0.0006	-0.04511 0.6911
Fe	0.00183 0.9871	-0.02486 0.8267	-0.03749 0.7413	-0.03328 0.7794	-0.00885 0.9379	0.07479 0.5097	0.08715 0.4421	0.12975 0.2513

Table 19. Correlation coefficients for soil and leaf nutrient concentration. Corn experiment No.2, 1977

CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / N = 80

Leaf	P	K	CA	MG	CU	ZN	MN	FE
					Soil			
P	0.19146 0.0889	-0.07242 0.5232	0.20646 0.0661	0.12472 0.2614	0.22185 0.0479	0.27089 0.0151	0.37394 0.0006	0.04422 0.6976
K	0.03561 0.7538	0.25360 0.0232	-0.01073 0.9248	0.07077 0.5337	-0.10675 0.3460	-0.12018 0.2883	0.00316 0.9778	-0.09088 0.4227
Ca	0.21704 0.0531	-0.28366 0.0108	0.13646 0.2275	-0.05031 0.6576	0.13098 0.1082	0.20549 0.0675	0.13155 0.2448	0.20991 0.0617
Mg	0.61228 0.0001	-0.17959 0.1109	0.62811 0.0001	0.48182 0.0001	0.68847 0.0001	0.77462 0.0001	0.47345 0.0001	0.65438 0.0001
Cu	-0.15770 0.1624	0.18244 0.1053	-0.15749 0.1630	-0.04371 0.7003	-0.10731 0.3434	-0.15330 0.1746	-0.08517 0.4525	-0.14653 0.1946
Zn	0.04999 0.6597	0.06953 0.5400	-0.01112 0.9220	-0.04622 0.6940	-0.12628 0.2643	-0.04822 0.6710	-0.06338 0.5765	0.00231 0.9449
Mn	0.06269 0.5807	-0.14122 0.2115	0.01287 0.9098	-0.04434 0.6961	0.06552 0.5616	0.08529 0.4519	0.14650 0.1947	-0.09900 0.3867
Fe	-0.03603 0.7510	0.14589 0.1966	-0.00930 0.4361	-0.02185 0.4178	-0.21749 0.0526	-0.14615 0.1958	0.02791 0.8059	-0.02689 0.9129

respectively. Management problems such as weed and water control plus a heavy infestation of sorghum midge caused grain yields to be low (Tables 20 and 26). In experiment No. 3, N was an important factor responsible for differences in the concentration of N, Ca, Mg, Zn, and Mn in the leaves as well as for differences in dry matter yield. Other significant effects and interactions are presented in Table 21.

Further analysis showed that when no K was added to the soil the different levels of N or P caused no differences in grain yield; however, when 60 kg/ K/ha was included in the fertilizer program, the addition of P caused a significant yield decrease (Table 22). This finding has been reported in the literature before (59) and possibly could be attributed to salinity problems. The effect of N levels on the concentrations of N, Ca, Mg, Zn, Mn in the leaves and dry matter yield is presented in Table 23. In all cases higher levels of N increased the concentration of the element and the dry matter yield. Terman and Noggle (61) found similar results when working with corn, in this case N caused an increase of P, Ca, and Mg concentrations in the leaves and a decrease in K concentration. The authors point out that these opposite trends indicate the reciprocal relationship between concentrations of K and Ca + Mg in plants. Differences caused by levels of P and K on Ca and Mg concentrations are shown in Table 24. Additions of P increased Ca concentrations and addition of K decreased Mg concentration. This latter relationship has been discussed before by Terman, Allen, and Bradford (59) who found marked reciprocal relationships between K-Mg, K-N, K-P, and K-Ca, and attributed them to ion antagonism. The K-Mg effect, the authors report, was most pronounced at higher K rates, no additional yield response occurred and resulted in

Table 20. Grain yield, dry matter yield, and nutrient concentration in leaves. Sorghum experiment No.3, 1977

Treatment 1/			Grain yield	Dry matter yield	Nutrient concentration at mid bloom								
N	P	K	(kg/ha)	(kg/ha)	N	P	K	Ca	Mg	Cu	Zn	Mn	Fe
					%					ppm			
0	0	0	332	3821	1.63	0.32	2.33	0.25	0.22	12.2	42	20	78
0	0	1	363	4399	1.65	0.30	2.37	0.25	0.21	12.6	35	21	78
0	1	0	305	3476	1.57	0.32	2.24	0.28	0.21	10.6	36	20	82
0	1	1	238	3771	1.57	0.34	2.36	0.23	0.19	11.6	37	20	80
1	0	0	254	4239	1.75	0.33	2.42	0.28	0.24	11.8	37	26	84
1	0	1	335	3949	1.70	0.31	2.38	0.25	0.21	11.8	39	20	74
1	1	0	318	3966	1.96	0.36	2.44	0.30	0.29	10.6	41	24	90
1	1	1	212	4248	1.83	0.29	2.46	0.28	0.25	11.8	50	29	88
2	0	0	344	5100	1.94	0.32	2.26	0.27	0.26	12.0	47	24	86
2	0	1	383	4796	1.99	0.31	2.34	0.27	0.24	12.0	56	27	84
2	1	0	327	4767	2.03	0.36	2.30	0.29	0.25	13.0	59	30	102
2	1	1	337	4894	1.83	0.32	2.46	0.29	0.25	11.6	58	32	100
3	0	0	320	4940	2.19	0.34	2.32	0.31	0.31	12.6	66	31	196
3	0	1	348	5133	2.05	0.33	2.12	0.27	0.25	10.6	45	27	84
3	1	0	371	4483	1.97	0.33	2.30	0.32	0.28	10.6	50	29	98
3	1	1	343	4597	2.25	0.33	2.40	0.34	0.30	9.6	54	33	102

1/ N 0, 1, 2, 3 = 0, 100, 200, 300 kg N/ha
P 0, 1 = 0, 60 kg P/ha
K 0, 1 = 0, 60 kg K/ha
Values are an average of 5 replications

Table 21. Significant variables as determined by F test. Sorghum experiment No.3, 1977

Source	D.F	N	P	K	Ca	Mg	Cu	Zn	Mn	Fe	Grain yield	Dry matter
		F-test on leaf nutrient concentration, grain and dry matter yields										
Rep	4											
TN		0.0001			0.0005	0.0001		0.0038	0.0004			0.0001
TP	1				0.0118							
TN x TP	3											
TK	1					0.0355						
TN x TK	3											
TP x TK	1										0.0440	
TN x TP x TK												

Table 22. Effect of K levels on grain yield at different levels of N and P. Sorghum experiment No.3, 1977

N	K = 0 kg/ha	K = 60 kg/ha
kg/ha	----------kg/ha----------	
0	319.1 a	301.2 a
100	286.5 a	273.5 a
200	336.0 a	360.4 a
300	346.2 a	346.2 a
P		
0	313.0 a	357.7 a
60	330.8 a	282.9 b

Means within each column for N or P treatments followed by different letters are significantly different according to Duncan's multiple range test.

Table 23. Effect of N levels on the concentration of nutrients in the leaves and in dry matter yield. Sorghum experiment No.3, 1977

N	N	Ca	Mg	Zn	Mn	Dry matter
kg/ha	----------%----------			-------ppm-------		kg/ha
0	1.61 c	0.26 b	0.21 c	37.8 b	20.6 c	3867 b
100	1.82 b	0.28 b	0.25 b	42.3 b	25.1 b	4102 b
200	1.95 b	0.28 b	0.25 b	55.5 a	28.5 b	4789 a
300	2.12 a	0.32 a	0.29 a	54.2 a	30.4 a	4890 a

Means followed by different letters are significantly different according to Duncan's multiple range test. Comparisons should be made within columns.

Table 24. Effect of P and K levels on the concentration of Ca and Mg. Sorghum experiment No.3, 1977

P	Ca	K	Mg
kg/ha	%	kg/ha	%
0	0.27 b	0	0.26 a
60	0.30 a	60	0.24 b

Means followed by different letters are significantly different according to Duncan's multiple range test. Comparisons should be made within columns.

decreased Ca, Mg, or P uptake. Soil test before planting (Table 25) may also help to explain some of the above mentioned relationships.

Experiment No. 4 grain yield, pH, soil test, and leaf nutrient concentrations are presented in Tables 26 and 27. Statistical results are shown in Table 28; N, and P to a lesser extent caused significant changes in several elements. Further analysis indicates that P increased Mg concentration at the higher level of N (Table 29), and that the addition of K fertilizer decreased Ca concentration in the leaves when no P was added (Table 31).

In the soil only Zn and Mn were significantly affected by levels of N. The 200 kg N/ha rate increased the concentrations of Zn and Mn in the soil. However, the lower and the higher levels produced the opposite effect (Table 30). A similar relationship was reported by Soltanpour (54) who found that Zn increased protein and nitrate N as a percentage of total N when applied together with N.

The correlation coefficients for soil test versus leaf nutrient concentrations (Table 32) differ from the previous corn experiments. In this case Ca in the leaves was closely correlated to the concentration of P, Ca, Mg, Cu, Zn, and Mn in the soil. Magnesium in the leaves was negatively correlated with K, Ca, Mg, and Zn in the soil. Copper and Zn were also negatively correlated. This last antagonistic effect has been reported before (34).

Sorghum experiment No. 5 had good overall management. However, a severe infestation by sorghum "midge" precluded getting higher grain yields. Total dry matter showed that marked differences occurred among the N levels. Yields, pH, soil test, and nutrient concentrations in the

Table 25. Soil analysis before planting. Sorghum experiment No.3 (tile drained), 1977

Rep	pH	P	K	Ca	Mg	Cu	Zn	Mn	Fe
		ppm							
I	5.5	100	153	818	116	0.36	2.6	2.3	69
II	5.3	142	149	820	100	0.28	2.6	2.6	54
III	5.3	124	156	740	92	0.20	2.7	2.2	56
IV	5.5	97	149	598	84	0.20	2.1	1.9	54
V	5.2	101	186	740	116	0.20	2.7	2.7	66
$\bar{X}$		113	159	743	102	0.25	2.5	2.3	60

Table 26. Grain yield, pH, and nutrient concentration in the soil. Sorghum experiment No.4,1977

Treatment 1/			Grain yield		Nutrient concentration in the soil (ppm) at harvest							
N	P	K	(kg/ha)	pH	P	K	Ca	Mg	Cu	Zn	Mn	Fe
0	0	0	1741	5.20	263	93	1298	146	0.52	4.10	3.76	41.2
0	0	1	1759	5.22	310	115	1375	165	0.49	4.28	3.54	43.4
0	1	0	1668	5.34	278	65	1433	144	0.58	4.20	3.98	40.2
0	1	1	1723	5.26	267	117	1323	186	0.47	3.82	3.60	49.4
1	0	0	2195	5.32	253	81	1256	156	0.47	4.04	3.64	41.4
1	0	1	1942	5.26	253	109	1291	184	0144	4.08	4.02	41.2
1	1	0	1417	5.24	266	80	1183	119	0.51	4.02	3.62	35.2
1	1	1	1420	5.16	284	80	1275	140	0.48	4.00	3.80	38.6
2	0	0	1500	5.20	256	123	1551	218	0.47	5.78	5.04	50.2
2	0	1	1981	5.26	251	79	1224	141	0.49	4.00	3.68	39.6
2	1	0	1791	5.26	233	76	1425	167	0.45	4.64	4.24	37.2
2	1	1	1409	5.10	271	118	1394	178	0.47	4.48	4.22	42.8
3	0	0	1379	5.16	235	97	1434	183	0.47	4.52	4.10	40.8
3	0	1	1853	5.12	276	96	1202	168	0.43	3.82	3.52	40.2
3	1	0	1725	5.24	243	61	1198	133	0.48	3.68	3.46	39.6
3	1	1	1100	5.14	271	96	1128	130	0.39	3.72	3.44	38.2

1/ N 0, 1, 2, 3 = 0, 100, 200, 300 kg N/ha
P 0, 1 = 0, 60 kg P/ha
K 0, 1 = 0, 60 kg K/ha
Values are an average of 5 replications

Table 27. Nutrient concentration in the leaves. Sorghum experiment No.4, 1977

Treatment 1/			Nutrient concentration at mid bloom								
N	P	K	N	P	K	Ca	Mg	Cu	Zn	Mn	Fe
			%					ppm			
0	0	0	2.11	0.35	1.73	0.49	0.31	15.6	196	65	72
0	0	1	2.06	0.34	1.78	0.47	0.32	15.2	204	80	78
0	1	0	2.04	0.38	1.78	0.55	0.37	14.0	195	68	76
0	1	1	1.93	0.33	1.73	0.50	0.29	17.0	206	66	82
1	0	0	2.21	0.33	1.72	0.59	0.36	16.4	204	89	88
1	0	1	2.04	0.32	1.88	0.46	0.29	14.8	210	67	74
1	1	0	2.09	0.38	1.79	0.50	0.35	17.0	256	83	74
1	1	1	2.42	0.39	1.80	0.56	0.34	17.0	244	97	83
2	0	0	2.36	0.34	1.72	0.59	0.34	13.6	264	101	102
2	0	1	2.40	0.33	1.70	0.55	0.37	11.4	252	87	86
2	1	0	2.30	0.44	1.88	0.53	0.34	10.0	244	100	90
2	1	1	2.45	0.36	1.57	0.51	0.30	10.4	252	103	74
3	0	0	2.54	0.37	1.79	0.52	0.29	11.0	246	99	92
3	0	1	2.38	0.30	1.77	0.53	0.32	11.8	244	89	84
3	1	0	2.19	0.39	1.68	0.56	0.38	13.6	254	110	92
3	1	1	2.41	0.40	1.66	0.58	0.40	18.8	264	104	90

1/ N 0, 1, 2, 3 = 0, 100, 200, 300 kg N/ha
P 0, 1 = 0, 60 kg P/ha
K 0, 1 = 0, 60 kg K/ha
Values are an average of 5 replications

Table 28. Significant variables as determined by the F test. Sorghum experiment No.4, 1977

Source	D.F	pH	N	P	K	Ca	MG	Cu	Zn	Mn	Fe	Grain yield
			F-test on pH, soil nutrients concentration, and grain yield									
Rep	4											
TN	3								0.0215	0.0120		
TP	1											
TN x TP	3											
TK	1											
TN x TK	3											
TP x TK	1											
Tn x TP x TL	3											
			F-test on leaf nutrients concentration									
Rep	4											
TN	3		0.0013					0.0236	0.0001	0.0016	0.0455	
TP	1			0.0008								
TN x TP	3						0.0092					
TK	1											
TN x TK	3											
TP x TK	1											
TN x TP x TK	3					0.0373						

Table 29. Significance of percent Ca and Mg in the leaves at 4 levels of N as determined by the F test. Sorghum fertility experiment No.4, 1977

		N = 0 kg/ha		N = 100 kg/ha		N = 200 kg/ha		N = 300 kg/ha	
Source	D.F	Ca	Mg	Ca	Mg	Ca	Mg	Ca	Mg
Rep	4								
TP	1								0.0225
TK	1								
TP x TK	1			0.00019					

Table 30. Effect of N levels on the concentration of Zn and Mn in the soil. Sorghum experiment No.4, 1977

N	Zn	Mn
kg/ha	ppm	
0	4.10 b	3.72 b
100	4.04 b	3.77 b
200	4.72 a	4.30 a
300	3.93 b	3.63 b

Means followed by different letters are significantly different according to Duncan's multiple range test. Comparisons should be made within columns.

Table 31. Effect of K on Ca leaf concentration at 2 levels of P. Sorghum experiment No.4, 1977

K	P = 0 kg/ha	P = 60 kg/ha
kg/ha	Ca %	
0	0.596 a	0.505 a
60	0.454 b	0.566 a

Means followed by different letters are significantly different according to Duncan's multiple range test. Comparisons should be made within columns.

Table 32. Correlation coefficients for soil and leaf nutrient concentrations. Sorghum experiment No.4, 1977

CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / N = 80

Leaf	P	K	CA	MG	CU	ZN	MN	FE
				Soil				
P	-0.26999 0.0158	-0.23403 0.0367	-0.22812 0.0418	-0.19382 0.0850	-0.21600 0.0543	-0.21087 0.0604	-0.11587 0.3060	-0.26216 0.0188
K	0.99441 0.9690	-0.19303 0.0862	-0.01911 0.8664	-0.04153 0.7145	-0.02698 0.8122	-0.03249 0.7748	-0.01225 0.9141	-0.16253 0.1497
Ca	0.44851 0.0001	-0.08956 0.4295	0.25721 0.0213	-0.22031 0.0496	0.42419 0.0001	0.37843 0.0005	0.29344 0.0082	0.06173 0.5864
Mg	-0.14339 0.2029	-0.27697 0.0129	-0.28060 0.0117	-0.34658 0.0016	-0.10797 0.3494	-0.22619 0.0437	-0.21603 0.0543	-0.16352 0.1472
Cu	-0.24917 0.0258	0.09358 0.4090	-0.21309 0.0577	0.05120 0.6519	-0.25166 0.0243	-0.24874 0.0261	-0.16705 0.1386	0.03223 0.7755
Zn	-0.28779 0.0094	0.04315 0.7039	-0.34117 0.0020	0.00524 0.9632	-0.41115 0.0002	-0.22426 0.0455	-0.11526 0.3086	0.04264 0.7073
Mn	-0.38476 0.0004	-0.13995 0.2157	-0.40340 0.0002	-0.10372 0.3599	-0.44640 0.0001	-0.34014 0.0020	-0.26245 0.0187	-0.16962 0.1329
Fe	0.02001 0.8601	-0.09701 0.4429	-0.03871 0.7332	-0.03960 0.7273	0.07815 0.4908	0.12477 0.2702	0.17457 0.1214	0.01099 0.9257

leaves are presented in Tables 33 and 34. Soil analysis before planting appear in Table 35. Nitrogen accounted for the majority of the significant effects (Table 36) both in the soil and the leaves. These results are in complete agreement with a report by Terman (60). The author reviewed over 100 reports of experiments with maize and cotton which indicated that the frequency and magnitude of crop responses to N were generally greater than those to P and K in representative cropping areas of the USA. Higher levels of N decreased pH in the soil; an effect previously noted in the literature (62), as well as K and Mg concentrations. On the other hand, it also increased grain and dry matter yield (Table 37). The effect of N levels on nutrient concentration in the leaves appears in Table 38 and it is clear that N, P, K, Ca, Mg, Mn, and Fe concentrations were increased by the higher rates of applied N. Reports on these kind of relationships vary depending upon conditions of a study. Larssen (34) found that high rates up to 500 kg N/ha did not appreciably influenced Ca and P. However, K was increased and Mg was decreased by N fertilizer.

Further analysis revealed that only at the 0 level of N did fertilizer P increase Ca and Fe concentrations in the soil, while at the 200 kg N/ha rate the addition of fertilizer K reduced extractable K in the soil (Table 39). Soil test Ca fertilizer remained the same at both levels of P and K (Table 40).

Correlation coefficients for soil and leaf nutrient concentrations as well as for pH, grain, and dry matter values appear in Table 41. Grain yield showed a high positive correlation with Ca, Mn, and Fe concentrations in the leaves and with dry matter yield but was not correlated with any particular element in the soil. Dry matter yield was positively correlated

Table 33. Grain yield, dry matter, pH, and nutrient concentration in the soil. Sorghum experiment No.5, 1977

Treatment 1/			Grain yield	Dry matter yield		Nutrient concentration in the soil (ppm) at harvest							
N	P	K	(kg/ha)	(kg/ha)	pH	P	K	Ca	Mg	Cu	Zn	Mn	Fe
0	0	0	324	3600	5.42	419	45	620	28	3.49	6.70	3.82	56.0
0	0	1	503	3459	5.47	413	51	645	29	3.56	7.17	4.00	54.7
0	1	0	367	3906	5.42	405	47	686	32	3.60	6.75	3.95	61.0
0	1	1	496	3535	5.27	367	54	671	30	4.00	7.27	4.12	60.2
1	0	0	644	4461	5.15	428	41	680	32	4.61	7.47	4.30	61.7
1	0	1	505	4219	5.32	390	47	619	29	3.17	6.32	3.87	57.5
1	1	0	528	3963	5.22	400	46	641	28	3.83	6.62	4.10	57.0
1	1	1	742	4195	5.30	413	48	700	29	4.03	7.25	4.20	61.5
2	0	0	603	4501	5.27	400	40	640	24	4.02	6.87	4.02	60.7
2	0	1	771	4265	5.42	409	44	725	30	3.70	6.67	3.92	59.5
2	1	0	617	5108	5.45	399	30	639	24	3.76	6.62	4.10	56.0
2	1	1	517	5222	5.47	373	41	616	23	3.73	6.35	3.77	55.5
3	0	0	901	5791	5.25	364	36	622	27	3.83	6.40	3.65	64.5
3	0	1	748	5643	5.22	472	45	667	28	4.33	7.10	4.22	61.5
3	1	0	900	5848	5.25	429	35	638	23	3.66	6.62	4.00	60.0
3	1	1	893	6008	5.30	376	39	648	28	3.58	6.22	3.77	61.2

1/ N 0, 1, 2, 3 = 0, 100, 200, 300 kg N/ha
P 0, 1 = 0, 60 kg P/ha
K 0, 1 = 0, 60 kg K/ha
Values are an average of 4 replications

Table 34. Nutrient concentration in the leaves. Sorghum experiment No.5, 1977

Treatment 1/			Nutrient concentration at mid bloom								
N	P	K	N	P	K	Ca	Mg	Cu	Zn	Mn	Fe
			%					ppm			
0	0	0	1.29	0.35	1.88	0.24	0.13	16.2	272	39	65
0	0	1	1.20	0.38	1.94	0.26	0.13	12.0	287	43	70
0	1	0	1.19	0.34	1.88	0.25	0.14	12.5	262	34	62
0	1	1	1.25	0.37	2.16	0.27	0.13	11.2	250	46	75
1	0	0	1.32	0.38	2.11	0.28	0.16	11.7	255	48	67
1	0	1	1.37	0.36	2.13	0.27	0.14	15.2	237	46	77
1	1	0	1.37	0.38	2.06	0.28	0.13	13.0	240	48	87
1	1	1	1.46	0.39	2.13	0.30	0.15	13.2	252	51	75
2	0	0	1.68	0.37	2.06	0.31	0.17	14.0	247	53	82
2	0	1	1.58	0.38	2.15	0.28	0.16	13.2	252	48	85
2	1	0	1.44	0.41	1.95	0.31	0.15	14.2	245	46	75
2	1	1	1.48	0.40	2.10	0.30	0.16	15.5	245	52	72
3	0	0	1.95	0.38	2.04	0.33	0.19	15.2	257	49	80
3	0	1	1.71	0.44	2.21	0.30	0.18	14.5	265	59	90
3	1	0	1.58	0.41	2.03	0.34	0.19	14.2	275	59	90
3	1	1	1.42	0.38	2.14	0.34	0.17	14.7	285	57	85

1/ N 0, 1, 2, 3 = 0, 100, 200, 300 kg N/ha
P 0, 1 = 0, 60 kg P/ha
K 0, 1 = 0, 60 kg K/ha
Values are an average of 4 replications

Table 35. Soil analysis before planting. Sorghum experiments No.4 (ditch drained), and No.5, 1977

Rep	pH	P	K	Ca	Mg	Cu	Zn	Mn	Fe
				Experiment No.4					
						ppm			
I	5.6	446	164	1842	180	0.92	6.3	5.4	38
II	5.2	228	190	1402	212	1.46	4.1	3.6	48
III	5.2	199	189	1326	180	0.32	4.1	3.5	38
IV	5.3	207	186	1544	180	0.52	4.0	4.1	36
V	5.3	197	161	1204	132	0.28	4.1	4.3	32
$\bar{X}$		255	178	1464	177	0.70	4.5	4.2	38
				Experiment No.5					
I	5.4	371	142	936	73	4.12	9.3	6.4	61
II	5.3	317	116	746	45	3.40	6.8	4.8	59
III	5.4	350	103	836	58	3.80	7.6	5.1	60
IV	5.5	329	98	748	45	3.24	6.7	4.9	59
$\bar{X}$		341	115	816	55	3.64	7.6	5.3	60

Table 36. Significant variables as determined by the F test. Sorghum experiment No.5, 1977

Source	D.F	pH	N	P	K	Ca	Mg	Cu	Zn	Mn	Fe	Grain yield	Dry matter
		F-test on pH, soil nutrients concentration, grain and dry matter yields											
Rep	4												
TN	3	0.0026			0.0001		0.0280					0.0001	0.0001
TP	1												
TN x TP	3										0.0243		
TK	1				0.0005								
TN x TK	3												
TP x TK	1												
TN x TP x TK	3					0.0229							
		F-test on leaf nutrients concentration											
Rep	4												
TN	3		0.0001	0.0403	0.0409	0.0001	0.0001			0.0001	0.0045		
TP			0.0492			0.0354							
TN x TP	3												
TK	1				0.0044								
TN x TK	3												
TP x TK	1												
TN x TP x TK	3												

Table 37. Effect of N levels on soil pH, grain, dry matter and K and Mg soil test. Sorghum experiment No.5, 1977

N	pH	grain	Dry matter	K	Mg
kg/ha			kg/ha	-----ppm-------	
0	5.40 a	423 c	3625 d	50 a	30 a
100	5.25 b	605 b	4210 c	46 a	30 a
200	5.41 a	627 b	4774 b	39 b	26 b
300	5.26 b	860 a	5823 a	39 b	27 ab

Means followed by different letters are significantly different according to Duncan's multiple range test. Comparisons should be made within columns.

Table 38. Effect of N levels on concentration of several elements in the leaves. Sorghum experiment No.5, 1977

N	N	P	K	Ca	Mg	Mn	Fe
kg/ha	----------%----------					-----ppm------	
0	1.23 b	0.36 b	1.97 b	0.26 c	0.13 d	41 c	68 b
100	1.38 b	0.38 ab	2.11 a	0.29 b	0.15 c	49 b	77 ab
200	1.55 a	0.39 ab	2.07 ab	0.30 b	0.16 b	50 b	79 a
300	1.67 a	0.41 a	2.11 a	0.33 a	0.18 a	56 a	86 a

Means followed by different letters are significantly different according to Duncan's multiple range test. Comparisons should be made within columns.

Table 39. Effect of N levels on the concentration of K, Ca, and Fe in the soil at 2 levels of P and K. Sorghum experiment No.5, 1977

P	N = 0 kg/ha			N = 100 kg/ha			N = 200 kg/ha			N = 300 kg/ha		
	K	Ca	Fe	K	Ca	Fe	K	Ca	Fe	K	Ca	Fe
kg/ha	ppm											
0	49 a	632 b	55 b	44 a	650 a	60 a	43 a	682 a	60 a	41 a	644 a	63 a
60	51 a	679 a	61 a	48 a	670 a	59 a	36 a	628 a	56 a	38 a	643 a	61 a
K												
0	47 a	653 a	57 a	44 a	660 a	59 a	35 b	640 a	58 a	36 a	630 a	62 a
60	53 a	658 a	58 a	48 a	660 a	59 a	43 a	670 a	57 a	43 a	658 a	61 a

Means within each column for P or K treatments followed by different letters are significantly different according to Duncan's multiple range test.

Table 40. Effect of levels of K on soil test Ca at 2 levels of P. Sorghum experiment No.5, 1977

K	P = 0 kg/ha	P = 60 kg/ha
kg/ha	ppm	
0	680 a	641 a
60	619 a	700 a

Means followed by different letters are significantly different according to Duncan's multiple range test. Comparisons should be made within columns.

Table 41. Correlation coefficients for soil and leaf nutrient concentrations, grain and dry matter yields. Sorghum experiment No.5, 1977

CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / N = 64

Leaf	PH	P	CA	MG	CU	ZN	MN	FE	GRAIN	DM
					Soil					
N	-0.12152 0.3398	0.17899 0.1573	0.20149 0.1124	0.00775 0.9515	0.18809 0.1367	0.06222 0.6252	0.02982 0.8211	-0.12500 0.3251	0.34567 0.0051	0.38081 0.0016
P	-0.11190 0.3787	0.10936 0.3897	0.07402 0.5619	-0.30269 0.0151	0.31556 0.0111	0.25344 0.0433	0.28765 0.0212	0.08934 0.4826	0.16256 0.1793	0.38157 0.0019
K	-0.59908 0.4160	0.26242 0.0362	0.52157 0.0001	0.28942 0.0234	0.47443 0.0001	0.52200 0.0001	0.50509 0.0001	-0.08516 0.5014	0.21261 0.0917	0.19631 0.1260
Ca	-0.14768 0.2449	0.16317 0.1977	0.20030 0.1125	-0.10709 0.3996	0.20503 0.1041	0.15422 0.2237	0.16630 0.1891	-0.03658 0.7741	0.26245 0.0001	0.54977 0.0001
Mg	-0.17375 0.1697	0.26068 0.0375	0.23460 0.0662	0.05365 0.6737	0.28653 0.0217	0.16324 0.1975	0.17228 0.1734	-0.06798 0.5935	0.49344 0.0001	0.49429 0.0001
Cu	0.10085 0.4278	0.25580 0.0413	0.01554 0.9030	-0.07099 0.5773	-0.05486 0.6668	-0.09107 0.4742	-0.08793 0.4797	-0.20750 0.0999	-0.12265 0.3343	0.10491 0.4094
Zn	0.21005 0.0957	0.46232 0.0001	0.40717 0.0008	0.46941 0.0036	0.10307 0.4140	0.21876 0.0824	0.14066 0.2676	-0.29139 0.0195	-0.09356 0.4822	0.02209 0.8824
Mn	-0.17421 0.1686	0.28369 0.0231	0.31261 0.0119	0.01989 0.8760	0.25868 0.0370	0.34157 0.0057	0.32478 0.0088	-0.12410 0.3286	0.48325 0.0001	0.39536 0.0012
Fe	-0.06476 0.6112	0.16578 0.1905	0.29747 0.0170	0.15230 0.2296	0.22693 0.0713	0.31204 0.0121	0.24350 0.0525	-0.02755 0.8289	0.42589 0.0005	0.32304 0.0765
Grain	-0.22973 0.0678	0.01844 0.8850	0.11094 0.3928	-0.01612 0.8994	0.12050 0.3629	0.15124 0.2329	0.04684 0.7132	0.14252 0.2613	1.00000 0.0001	0.58614 0.0001
D M	-0.16941 0.1808	-0.04067 0.7497	0.02598 0.8385	-0.15470 0.2222	0.24949 0.0468	0.09804 0.4497	0.14002 0.2698	0.38166 0.0019	0.58614 0.0001	1.00000 0.0001

with N, P, Ca, and Mn concentrations in the leaves as well as with grain yield and with Cu and Fe in the soil.

Fertility Experiments in 1978

Corn

Adequate water, weed and insect management allowed good responses to treatments imposed in the 1978 study (Table 42). Soil test before planting is shown in Table 43. Nitrogen was responsible for increased grain and dry matter yields (Tables 44, and 45). The first increment of N(100 kg/ha) was sufficient to maximize grain and dry matter yields; higher rates were not statistically different. The 100 kg N/ha seemed to be a consistent figure to obtain highest yields for both corn and sorghum in this area. This result differes from an earlier report by Guzman et al. (21) that recommended 179 kg N/ha for top yields on Florida's sandy soils. Rhoads (48) proposed applying N in North Florida soils according to corn plant population. For 29,640, 59,280, and 88,920 plants/ha the amounts of N should be 89, 178, and 267 kg N/ha respectively for yields up to 12,500 kg/ha.

Further analysis were conducted, due to significance of the triple interaction NxPxK (Table 46), to determine the effect of N levels at different levels of P and K. Even though no significant differences were found in this case (Table 45), as they were in experiment No. 3, it appeared to be a clear tendency for P and K to diminish grain and dry matter yields. These effects are depicted in Figure 1 to 6 and are found in several literature reports (8, 11, 47).

Table 42 Grain and dry matter yield. Corn experiment No. 8, 1978

Treatments 1/			Grain yield	Dry matter
N	P	K	kg/ha	kg/ha
0	0	0	4287	11227
0	0	1	4137	11353
0	1	1	4845	11438
0	1	1	2982	9535
1	0	0	6089	14123
1	0	1	5316	14389
1	1	0	5525	16039
1	1	1	5712	14252
2	0	0	6689	14194
2	0	1	5231	14630
2	1	0	4795	14177
2	1	1	6028	17726
3	0	0	5996	13313
3	0	1	5956	14485
3	1	0	5642	14940
3	1	1	4258	13952

1/ N 0, 1, 2, 3 = 0, 100, 200, 300 kg/ha
P 0, 1 = 0, 60 kg/ha
K 0, 1 - 0, 60 kg/ha
Values are an average of five replications

Table 43 Soil analysis before planting, Corn fertility experiment No.8, 1978

Rep	pH	P	K	Ca	Mg	Cu	Zn	Mn	Fe
		ppm							
I	5.6	394	120	1208	92	2.2	7.6	3.1	32
II	5.5	334	188	1312	104	2.2	6.8	3.2	24
III	5.6	398	172	1508	120	3.5	7.2	3.9	40
IV	5.6	274	136	1040	92	1.8	4.8	2.3	26
$\bar{X}$		354	149	1269	103	2.4	6.6	3.1	29

Table 44. Effect of N levels and percent lodging on grain, and dry matter yields. Corn experiment No.8, 1978

N	Grain yield	Dry matter yield	Lodging percent
kg/ha	-------kg/ha--------		
0	4063 b	10888 b	8
100	5660 a	14700 a	20
200	5686 a	15180 a	35
300	5463 a	14172 a	41

Means followed by different letters are significantly different according to Duncan's multiple range test. Comparisons should be made withing columns.

Table 45. Effect of N levels on grain and dry matter yields at 2 levels of P and K. Corn experiment No.8, 1978

P	N = 0 kg/ha		N = 100 kg/ha		N = 200 kg/ha		N =300 kg/ha	
	Grain	Dry matter	Grain	Dry matter	Grain	Dry matter	Grain	Dry matter
kg/ha	kg/ha							
0	4212 a	11290 a	5703 a	14255 a	5960 a	14413 a	5976 a	13899 a
60	3913 a	10487 a	5618 a	15146 a	5412 a	15952 a	4950 a	14446 a
K								
0	4566 a	11333 a	5807 a	15081 a	5742 a	14186 a	5819 a	14127 a
60	3560 a	10444 a	5516 a	14320 a	5630 a	16178 a	5107 a	14218 a

Means within each column for P or K treatments followed by different letters are significantly different according to Duncan's multiple range test.

Table 46. Significance of agronomic variables as determined by the F test. Corn experiment No.8, 1978

Source	D.F	Grain yield	Dry matter yield
Rep	4		
N	3	0.0003	0.0001
P	1		
N x P	3		
K	1		
N x K	3		
P x K	1		
N x P x K	3	0.0276	

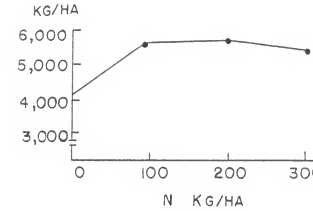

Figure 1. Effect of N levels on grain yield. Corn experiment No.8, 1978

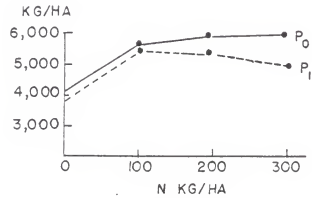

Figure 2. Effect of N levels on grain yield at two levels of P. Corn experiment No.8, 1978

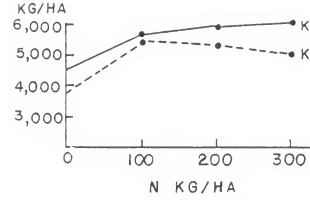

Figure 3. Effect of N levels on grain yield at two levels of K. Corn experiment No.8, 1978

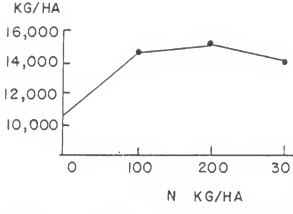

Figure 4. Effect of N levels on dry matter yield. Corn experiment No.8, 1978

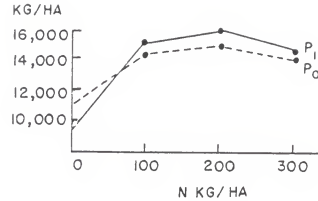

Figure 5. Effect of N levels on dry matter yield at two levels of P. Corn experiment No.8, 1978

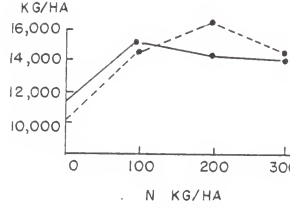

Figure No.6. Effect of N levels on dry matter yield at two levels of K. Corn experiment No.8, 1978

Regression analysis was conducted in order to find suitable prediction equations. However, the results came far short from this objective.

A highly significant linear N effect and a significant quadratic N effect were detected on dry matter yield. A stepwise regression analysis was run in order to find the individual contribution of the variables in the model. When the variable N was entered the prediction equation was

$Yi = 4{,}584.3 + 4.22\ N$ where

Yi = dry matter and N = fertilizer N

However, the $R^2 = 0.078$ was very low and most of the variability remains unaccounted for. When N and N^2 were entered, the prediction equation became

$Yi = 4{,}129 + 17.87\ N - 0.045N^2$ where

Yi = dry matter and N = fertilizer N

The $R^2 = 0.151$ was still very low. When all other possible variables were entered, the maximum R^2 obtained was only $R^2 = 0.218$.

Highly significant linear and quadratic N effects were also detected on grain yield. When N was entered, the equation was:

$Yi = 12{,}186.0 + 10.33\ N$

where Yi = grain and N = fertilizer N

The $R^2 = 0.114$ did not help again to explain much variability.

When N and N^2 were entered, the prediction equation became

$Yi = 10{,}980 + 46.49\ N - 0.12\ N^2$ where

Yi = grain and N = fertilizer N

Again the $R^2 = 0.239$ was very low. When all other possible variables were considered, the maximum R^2 possible was $R^2 = 0.278$, indicating that the above equations did not account for most of the variability.

Nutrient concentration values and statistical analysis for soil test and leaf samples are presented in Tables 47, 48, and 49. Nitrogen fertilizer again was responsible for most differences, especially in leaf analysis where it increased the concentration of N, P, Ca, Zn, and Mn, and decreased K.

Nutrient content (dry matter x nutrient concentration) values are shown in Table 50 and correspond to the amount of nutrients removed by each treatment. Nitrogen removal ranged from 100 to 248 kg/ha, P from 30 to 52 kg/ha, and K from 145 to 227 kg/ha, Ca and Mg were also removed in large amounts. It was not surprising to find that N caused most differences in nutrient content (Table 49). It was found to increase the content of N, P, K, Ca, Mg, Cu, Zn, Mn, and Fe in whole plant samples. The percent IVOMD values are included in Table 50 and were only decreased by K fertilizer (Table 49).

Correlation coefficients for soil and leaf nutrient concentrations (Table 51) show several significant effects. Manganese in the leaves was positively correlated with a few elements in the soil, namely Ca, Mg, Zn, and Mn. Soil versus whole plant nutrient content correlations (Table 52) show N content in whole plants to be negatively correlated with K in the soil and positively with grain and dry matter yield as well as with percent lodging. Also grain yield and dry matter showed a positive correlation, the R value being equal to 0.60.

Table 53 contains the correlation coefficients for leaf nutrient concentrations and whole plant nutrients content. Nitrogen content in whole plants was positively correlated with several elements but especially with N in the leaf samples ($R = 0.68$). At the same time, N in

Table 47. pH values, and nutrient concentration in the soil. Corn experiment No.8, 1978

Treatment 1/				Nutrient concentration in the soil (ppm) at harvest							
N	P	K	pH	P	K	Ca	Mg	Cu	Zn	Mn	Fe
0	0	0	5.28	421	76	1518	164	2.66	7.92	3.86	39.4
0	0	1	5.34	433	117	1485	129	2.58	8.08	4.16	28.4
0	1	0	5.34	443	85	1520	161	2.68	7.52	3.96	38.0
0	1	1	5.24	458	126	1452	155	2.36	7.20	3.90	32.4
1	0	0	5.26	415	66	1401	130	2.64	7.20	3.86	37.6
1	0	1	5.24	409	89	1492	167	2.50	7.12	3.74	36.4
1	1	0	5.22	437	55	1408	172	2.42	7.04	4.08	29.4
1	1	1	5.22	419	83	1438	164	2.60	6.80	3.76	35.0
2	0	0	4.98	394	64	1361	148	2.48	6.96	4.18	38.2
2	0	1	5.10	416	85	1492	197	2.38	7.12	4.16	33.8
2	1	0	5.04	478	60	1459	144	2.74	8.00	4.34	34.4
2	1	1	5.10	383	58	1330	117	2.60	6.88	3.84	33.2
3	0	0	5.00	416	62	1464	156	3.00	7.84	4.64	30.0
3	0	1	5.02	367	68	1350	116	2.26	6.88	4.00	31.2
3	1	0	4.92	456	57	1493	164	2.18	7.68	4.60	27.0
3	1	1	5.04	460	103	1501	186	2.80	8.00	5.46	36.4

1/ N 0, 1, 2, 3 = 0, 100, 200, 300 kg N/ha
P 0, 1 = 0, 60 kg P/ha
K 0, 1 = 0, 60 kg K/ha
Values are an average of 5 replications

Table 48. Nutrient concentration in the leaves. Corn experiment No.8, 1978

Treatment 1/			Nutrient concentration in the leaves at silk								
N	P	K	N	P	K	Ca	Mg	Cu	Zn	Mn	Fe
			%					ppm			
0	0	0	2.46	0.31	1.68	0.55	0.34	14.4	85	49	108
0	0	1	2.28	0.32	1.81	0.54	0.29	15.4	84	38	104
0	1	0	2.50	0.35	1.74	0.59	0.35	15.8	87	35	116
0	1	1	2.08	0.33	1.93	0.47	0.30	14.4	81	32	94
1	0	0	2.94	0.40	1.70	0.70	0.37	17.6	94	46	132
1	0	1	2.77	0.37	1.79	0.62	0.37	17.0	96	51	132
1	1	0	2.67	0.39	1.78	0.69	0.40	17.2	98	67	126
1	1	1	2.68	0.38	1.98	0.63	0.33	21.8	94	59	118
2	0	0	3.03	0.37	1.56	0.64	0.36	17.2	136	62	132
2	0	1	3.01	0.38	1.72	0.64	0.33	18.4	104	59	124
2	1	0	3.19	0.37	1.59	0.57	0.29	16.2	135	66	138
2	1	1	2.93	0.39	1.63	0.63	0.34	16.8	102	54	114
3	0	0	3.04	0.38	1.65	0.71	0.32	17.8	112	72	180
3	0	1	2.97	0.40	1.69	0.67	0.34	18.4	105	74	122
3	1	0	2.01	0.38	1.64	0.69	0.36	17.8	102	75	136
3	1	1	3.09	0.42	1.65	0.65	0.30	16.8	100	63	128

1/ N 0, 1, 2, 3 = 0, 100, 200, 300 kg N/ha
P 0, 1 = 0, 60 kg P/ha
k 0, 1 = 0, 60 kg K/ha
Values are an average of 5 replications

Table 49. Significant variables as determined by the F test. Corn experiment No.8, 1978

Source	D.F	pH	N	P	K	Ca	Mg	Cu	Zn	Mn	Fe	Percent IVOMD
F-test on pH, soil nutrients concentration and percent IVOMD												
Rep	4											
TN	3	0.0001			0.009					0.0280		
TP	1			0.0309								
TN x TP	3											
TK	1				0.0001							
TN x TK	3											
TP x TK	1											
TN x TP x TK	3											
F-test on leaf nutrients concentration												
Rep	4											
TN	3		0.0001	0.0001	0.0417	0.0001	0.0149	0.0068	0.0012	0.0001		
TP	1											
TN x TP	3											
TK	1		0.0345		0.0479		0.0206					
TN x TK	3											
TP x TK	1											
TN x TP x TK	3											

Table 49. (continued)

Source	D.F	pH	N	P	K	Ca	Mg	Cu	Zn	Mn	Fe	Percent IVOMD
				F-test on whole plant nutrient content								
Rep	4											
TN	3		0.0001	0.0013		0.0001	0.0001	0.0117	0.0001	0.0016	0.0021	
TP	1			0.0323								
TN x TP	3											
TK	1											0.0498
TN x TK	3											
TP x TK	1											
TN x TP x TK	3											

Table 50. Nutrient content and % IVOMD values for whole plant samples. Corn experiment No. 8, 1978.

Treatment 1/			Nutrient content (kg/ha) at harvest									Percent
N	P	K	N	P	K	Ca	Mg	Cu	Zn	Mn	Fe	IVOMD
0	0	0	100.36	30.13	145.45	20.28	17.73	0.116	0.390	0.376	1.091	71.73
0	0	1	99.92	33.28	165.60	24.71	20.28	0.119	0.386	0.359	0.934	70.95
0	1	0	105.04	32.87	171.59	24.05	22.27	0.118	0.429	0.271	1.294	71.76
0	1	1	80.16	30.75	149.96	20.92	19.72	0.106	0.382	0.227	1.157	70.00
1	0	0	177.05	39.47	176.33	34.54	32.14	0.170	0.621	0.403	1.782	72.08
1	0	1	175.02	32.26	196.51	31.01	29.19	0.162	0.542	0.396	1.252	71.72
1	1	0	193.65	48.86	195.28	38.59	37.46	0.179	0.606	0.510	1.650	71.68
1	1	1	151.01	34.80	182.16	31.54	28.55	0.130	0.471	0.330	1.485	71.37
2	0	0	195.59	46.44	155.74	34.93	34.43	0.142	0.599	0.438	1.461	72.36
2	0	1	204.70	40.68	208.53	44.16	35.70	0.160	0.723	0.522	2.240	71.09
2	1	0	196.70	41.05	177.22	31.35	28.82	0.138	0.539	0.388	1.399	72.56
2	1	1	248.10	62.39	227.38	43.33	39.49	0.231	0.696	0.579	1.674	71.72
3	0	0	200.15	42.12	170.58	43.93	35.06	0.148	0.674	0.470	2.381	71.03
3	0	1	193.67	34.69	185.27	33.98	30.66	0.217	0.573	0.442	1.465	69.24
3	1	0	237.95	51.77	216.52	50.37	42.87	0.178	0.708	0.588	1.870	72.88
3	1	1	213.39	45.19	185.60	46.90	35.69	0.159	0.757	0.571	1.902	71.00

1/ N 0, 1, 2, 3 = 0, 100, 200, 300 kg N/ha
P 0, 1 = 0, 60 kg P/ha
K 0, 1 = 0, 60 kg K/ha
Values are an average of 5 replications

Table 51. Correlation coefficients for soil and leaf nutrient concentrations. Corn experiment No.8, 1978.

CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / N = 80

Leaf	PH	P	K	CA	MG	CU	ZN	MN	FE
					Soil				
N	-0.47714 0.0001	-0.03256 0.7743	-0.26154 0.0191	0.06597 0.5608	0.05358 0.6369	0.09793 0.3875	0.03080 0.7863	0.22991 0.0402	0.05868 0.6051
P	-0.23604 0.0350	-0.00305 0.9786	-0.21887 0.0511	-0.04200 0.7115	-0.09915 0.3813	0.02609 0.8183	0.02619 0.8177	0.19331 0.0935	-0.12482 0.2700
K	-0.04654 0.6819	0.08283 0.4651	0.21285 0.0580	0.12267 0.2783	0.07732 0.4954	-0.04752 0.6755	0.16795 0.1364	0.14695 0.1934	-0.17219 0.1267
Ca	-0.09148 0.4197	-0.02326 0.8377	-0.25018 0.0252	-0.02179 0.8479	0.06269 0.5809	-0.00532 0.9627	0.04087 0.7321	0.10239 0.3561	-0.03708 0.7387
Mg	0.15337 0.1744	-0.09977 0.3796	-0.16085 0.1541	0.01961 0.8699	0.22950 0.0406	-0.26631 0.0170	-0.15076 0.1819	-0.18129 0.0944	-0.03500 0.7534
Cu	-0.03847 0.7348	-0.24072 0.0315	-0.11509 0.3094	-0.23249 0.0380	-0.02141 0.8505	-0.24619 0.0277	-0.15956 0.1574	-0.11277 0.3193	-0.22388 0.0459
Zn	-0.23650 0.0100	0.13849 0.2205	-0.00059 0.9937	0.21640 0.0539	0.16365 0.1469	0.11053 0.3290	0.30357 0.0062	0.41313 0.0001	-0.00729 0.4414
Mn	-0.61585 0.0001	0.18785 0.0952	0.01455 0.8981	0.39257 0.0003	0.34619 0.0017	0.15006 0.1840	0.27605 0.0132	0.43945 0.0001	-0.05054 0.6562
Fe	-0.18792 0.0951	0.03586 0.7521	-0.13319 0.2389	0.10106 0.3724	-0.00613 0.9570	0.15401 0.1726	0.01177 0.4796	0.18724 0.0963	0.01755 0.3772

Table 52. Correlation coefficients for soil, whole plant nutrient concentration and agronomic responses. Corn experiment No.8, 1978

CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / N = 80

Nutrient conc.	PH	P	K	CA	MG	OM	ZN	MN	FE	Y1 Grain	Y2 DM	Y3 Lodging
						soil						
N	-0.49517 0.0001	-0.09121 0.4739	-0.13215 0.2814	-0.09994 0.3973	-0.01311 0.9042	-0.06139 0.5935	-0.12011 0.2986	0.11090 0.3342	-0.09446 0.4045	0.27246 0.0145	0.30713 0.0056	0.44092 0.0001
P	-0.32712 0.0424	0.12508 0.2689	-0.16030 0.1563	-0.05240 0.6344	-0.29732 0.0658	0.08356 0.4598	0.06591 0.5667	0.07059 0.5349	-0.07046 0.5345	0.05965 0.5573	0.11723 0.3004	0.09111 0.4183
K	-0.00205 0.9699	0.27203 0.0146	0.13421 0.2012	0.24149 0.0361	0.01466 0.8973	0.16913 0.1333	0.06316 0.5778	0.17348 0.1195	0.04523 0.6694	-0.09331 0.4119	-0.03671 0.7297	0.02060 0.8551
Ca	-0.41447 0.0001	0.03719 0.7419	-0.23093 0.0590	-0.09028 0.4052	-0.04214 0.7009	0.04557 0.6911	-0.15386 0.1596	0.11121 0.3260	0.00447 0.9686	0.12583 0.2651	0.11357 0.3158	0.18579 0.1093
Mg	-0.33195 0.0384	-0.06346 0.5760	-0.27010 0.0174	-0.07826 0.4827	-0.01132 0.9047	-0.02152 0.8534	-0.24105 0.0314	-0.07521 0.5073	0.04581 0.6866	0.08172 0.4711	0.03813 0.7390	0.08619 0.4584
Cu	-0.34037 0.7222	-0.12916 0.2528	-0.09846 0.4315	-0.14319 0.1996	-0.05537 0.6237	-0.06541 0.5641	-0.00995 0.9421	-0.01362 0.9095	-0.01432 0.8997	-0.04962 0.6620	-0.00932 0.9415	-0.01685 0.8821
Zn	-0.15624 0.4012	0.15910 0.1595	-0.09641 0.7549	0.25593 0.0220	0.27403 0.0139	0.05932 0.5977	0.02239 0.8417	0.21423 0.0564	0.07541 0.5051	-0.01011 0.9210	-0.01152 0.9102	0.30237 0.0064
Mn	-0.42148 0.0001	0.13127 0.2458	-0.16211 0.1533	0.14385 0.2295	-0.08845 0.4711	0.21690 0.0562	0.06503 0.5666	0.27309 0.0142	0.07747 0.4986	0.09332 0.4094	0.20040 0.0747	0.19915 0.0763
Fe	-0.32459 0.0453	0.12029 0.2879	0.02813 0.8432	0.19028 0.0900	0.14133 0.2397	0.19630 0.0981	0.14423 0.2918	0.25898 0.0190	0.11534 0.3981	-0.04534 0.6897	-0.00829 0.9509	0.23415 0.0360
Grain	-0.20227 0.0720	0.06081 0.5942	-0.23330 0.0604	0.05967 0.5990	-0.10102 0.3694	0.31579 0.0083	0.02938 0.7959	0.07257 0.5281	0.13297 0.2397	1.00000 0.0001	0.00335 0.0001	0.19819 0.0730
DM	-0.12089 0.0771	0.07522 0.5073	-0.19519 0.1691	0.10336 0.1307	0.02875 0.8031	0.16013 0.1560	0.11291 0.3226	0.19005 0.0814	0.01496 0.8952	0.00325 0.0001	1.00000 0.0001	0.25907 0.0293
Lodg.	-0.36952 0.1001	0.20576 0.0103	0.12256 0.1631	0.16496 0.0308	0.30625 0.0057	0.13004 0.2581	0.40297 0.0005	0.31091 0.0001	-0.09634 0.3921	0.19819 0.0730	0.25909 0.0293	1.00000 0.0001

Table 53. Correlation coefficientes for leaf nutrient concentration, whole plant nutrient concentration and agronomic responses. Corn experiment No.8, 1978

CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 /N=80

Nutrient conc.	L1	L2	L3	L4	L5	L6	L7	L8	L9
					Leaf				
N	0.66671 0.0001	0.35746 0.0011	-0.13211 0.2826	0.26096 0.0019	0.06913 0.5425	0.10937 0.3330	0.13464 0.2299	0.43959 0.0001	0.40330 0.0001
P	-0.00365 0.9739	-0.01564 0.8905	-0.12343 0.1063	-0.09283 0.4123	-0.17031 0.1167	-0.25113 0.0249	-0.02390 0.8291	0.07308 0.5194	0.05573 0.6196
K	-0.15092 0.1815	0.01400 0.9019	0.15747 0.1639	-0.17550 0.1201	-0.17103 0.1293	-0.21114 0.0601	-0.16137 0.1527	0.16311 0.1479	0.11277 0.3323
Ca	0.34557 0.0017	0.23563 0.0354	-0.13535 0.2293	0.19568 0.1410	-0.06224 0.5817	-0.02587 0.8191	-0.14283 0.1945	0.22169 0.0481	0.17994 0.1107
Mg	0.28722 0.0093	0.08409 0.4563	-0.13089 0.2427	0.10817 0.3395	0.10089 0.3736	-0.04834 0.6923	-0.30839 0.0053	0.09559 0.3970	0.09089 0.4209
Cu	0.09161 0.4194	-0.12340 0.2755	-0.16736 0.1405	0.11990 0.2874	0.01404 0.9017	-0.02709 0.8121	0.11467 0.3111	-0.02606 0.8185	-0.04178 0.6998
Zn	0.37020 0.0007	0.14146 0.2197	-0.13815 0.1694	0.14376 0.2033	0.00510 0.9635	-0.14034 0.2124	-0.03902 0.7015	0.15974 0.0919	0.24476 0.0267
Mn	0.27619 0.0141	0.29268 0.0084	-0.03989 0.7856	0.10217 0.3651	-0.13743 0.2239	-0.18495 0.1097	0.04544 0.6890	0.44731 0.0001	0.18845 0.0972
Fe	0.09333 0.4179	0.05896 0.6034	0.13477 0.2196	-0.02763 0.8074	-0.13762 0.2235	0.05357 0.6379	0.25094 0.0439	0.19659 0.0910	-0.06941 0.5507
Grain	0.35296 0.0013	0.13228 0.2426	-0.16318 0.1481	0.20483 0.0194	0.06686 0.5557	0.09102 0.5995	0.09849 0.5669	0.29341 0.0196	0.26093 0.0158
DM	0.38580 0.0004	0.45549 0.0001	0.00724 0.9491	0.31157 0.0049	0.09437 0.4568	0.27493 0.0135	0.30180 0.0065	0.41445 0.0001	0.13137 0.2502
Lodg.	0.59221 0.0001	0.35606 0.0012	0.08467 0.4562	0.11277 0.3193	-0.19397 0.1359	-0.01449 0.8985	0.43630 0.0001	0.06980 0.0001	0.39913 0.0002

in the leaf was positively correlated with Ca, Mg, Zn, and Mn in the whole plant samples, as well as with dry matter and grain yield.

Sorghum

This fertility experiment planted at the ARC also had good overall management in 1978. Soil analysis before planting is presented in Table 54. Soil, leaf, and whole plant analysis, grain and dry matter yield, and percent IVOMD appear in Table 55. Both N and K fertilizer affected elements in leaf and whole plant while N mostly affected responses in soil samples. Even though this was the trend for most fertility experiments reported before, it appeared that K had a more definite role in this particular case. Values for nutrient concentration among the samples are shown in Tables 56, 57, and 58. Grain and dry matter yields appear also in Table 56 and followed a similar pattern to the 1977 previous experiments in which the first N increment (100 kg/ha) was enough to obtain maximum yields.

Further statistical analysis was conducted taking into account significant factors from the ANOVA tables. In the soil, high rates of N caused a decrease in K and Mg concentration at both 0 and 60 kg K/ha, but Fe concentration remained unchanged (Table 59). In the same table is shown that the 60 kg P/ha only decreased Mg concentration at the 0 level of K. On the other hand, Mn concentration increased with increasing rates of N at the 0 level of P (Table 60). Changes in pH, Ca, and Mg in the soil as affected by N levels appear in Table 61, and follow the same pattern already discussed in the 1977 data and found in several literature reports (5, 34, 62).

Table 54. Soil analysis before planting. Sorghum fertility experiment No.9, 1978

Rep	pH	P	K	Ca	Mg	Cu	Zn	Mn	Fe
		ppm							
I	5.3	100	84	736	100	3.9	8.8	3.7	40
II	5.1	260	76	556	68	3.7	8.0	3.5	40
III	5.5	264	76	664	76	4.2	8.0	3.0	44
IV	5.5	270	96	592	80	3.6	6.8	3.4	84
$\bar{X}$		223	83	637	81	3.8	7.9	3.4	52

Table 55. Significant variables as determined by the F test. Sorghum experiment No.9, 1978

Source	D.F	pH	N	P	K	Ca	Mg	Cu	Zn	Mn	Fe	Grain yield	Dry matter	IVOMD
F-test on Ph, soil nutrients concentration, grain and dry matter yield, and percent IVOMD														
Rep	4													
TN	3	0.0001			0.0001	0.0037	0.0001					0.0001	0.0001	
TP	1												0.0363	
TN x TP	3									0.0219				
TK	1				0.0001									
TN x TK	3				0.0186									
TP x TK	1						0.0453							
TN x TP x TK	3													
F-test on leaf nutrients concentration														
Rep	4													
TN	3		0.0001	0.0001		0.0001	0.0001	0.0031	0.0066	0.0001	0.0001			
TP	1													
TN x TP	3			0.0254										
TK	1			0.0016	0.0004	0.0001	0.0001							
TN x TK	3						0.0395							
TP x TK	1									0.0205				
TN x TP x TK	3			0.00037										

Table 55. (continued)

Source	D.F	pH	N	P	K	Ca	Mg	Cu	Zn	Mn	Fe	Grain yield	Dry matter	IVOMD
						F-test on whole plant nutrient concentration								
Rep	4													
TN	3		0.0001	0.00091			0.0001		0.0026	0.0001	0.0063			
TP	1													
TN x TP	3			0.0448			0.0304		0.0036					
TK	1				0.0064	0.0056	0.0004							0.0255
TN x TK	3													
TP x TK	1													
TN x TP x TK	3										0.0247			

Table 56. Grain and dry matter yield, pH, and nutrient concentration in the soil. Sorghum experiment No.9, 1978

Treatment[1/]			Grain yield	Dry matter yield		Soil test at harvest							
N	P	K	(kg/ha)	(kg/ha)	pH	P	K	Ca	Mg	Cu	Zn	Mn	Fe
0	0	0	1646	6562	5.80	300	34	637	71	4.35	7.50	2.82	41.2
0	0	1	1521	5682	5.62	290	45	665	63	3.70	8.40	2.57	44.0
0	1	0	1626	6520	5.72	298	33	652	66	4.60	9.10	2.82	46.0
0	1	1	1621	7380	5.82	328	62	733	77	4.75	8.90	3.07	46.0
1	0	0	3728	8619	5.50	308	25	692	65	4.55	7.80	3.00	47.0
1	0	1	3691	8936	5.55	302	32	654	65	3.77	8.30	2.70	42.0
1	1	0	3849	8432	5.57	306	32	675	63	4.12	8.10	3.05	43.0
1	1	1	3744	9466	5.57	304	33	689	65	4.35	8.90	3.17	46.0
2	0	0	3727	8540	5.45	320	25	714	65	5.15	8.00	3.22	47.0
2	0	1	3760	8810	5.52	291	33	641	62	3.90	7.90	3.10	40.7
2	1	0	3768	8412	5.45	279	22	613	55	3.95	7.60	2.55	42.2
2	1	1	4175	8968	5.55	285	30	640	57	3.75	8.00	2.95	44.0
3	0	0	4172	5776	5.27	283	24	622	55	4.05	8.10	2.50	46.0
3	0	1	3958	8070	5.22	300	28	615	49	4.15	7.70	3.40	44.0
3	1	0	3716	9106	5.22	300	22	604	48	4.15	7.00	3.02	41.0
3	1	1	3950	8748	5.22	275	28	582	53	3.87	8.50	2.82	43.2

1/ N 0, 1, 2, 3 = 0, 100, 200, 300 kg N/ha
P 0, 1 = 0, 60 kg P/ha
K 0, 1 = 0, 60 kg K/ha
Values are an average of 4 replications

Table 57. Nutrient concentration in the leaves. Sorghum experiment No.9, 1978

Treatment 1/			Nutrient concentration in the leaves at mid bloom							
N	P	K	N	P	K	Ca	Mg	Cu	Zn	Mn	Fe
			%					ppm			
0	0	0	1.45	0.36	1.52	0.19	0.20	11.5	137	40	80
0	0	1	1.35	0.33	1.64	0.18	0.15	10.0	116	45	67
0	1	0	1.26	0.35	1.63	0.20	0.18	12.2	117	46	67
0	1	1	1.46	0.37	1.76	0.19	0.19	13.0	125	44	72
1	0	0	2.43	0.55	1.65	0.31	0.40	15.2	130	54	92
1	0	1	2.48	0.52	1.93	0.26	0.33	14.2	132	48	95
1	1	0	2.50	0.59	1.63	0.36	0.47	14.5	135	65	112
1	1	1	2.36	0.55	1.85	0.28	0.35	13.2	132	53	107
2	0	0	2.82	0.65	1.61	0.32	0.44	13.7	147	52	117
2	0	1	2.86	0.61	1.81	0.28	0.36	14.2	142	52	110
2	1	0	2.76	0.60	1.64	0.33	0.45	14.2	135	52	125
2	1	1	2.74	0.59	1.63	0.28	0.31	12.5	120	48	92
3	0	0	2.67	0.66	1.71	0.33	0.42	14.7	137	55	97
3	0	1	3.06	0.67	1.95	0.31	0.35	15.5	150	65	100
3	1	0	3.00	0.72	1.65	0.35	0.46	15.0	157	65	102
3	1	1	2.89	0.60	1.70	0.29	0.34	13.7	140	52	122

1/ N 0, 1, 2, 3 = 0, 100, 200, 300 kg N/ha
P 0, 1 = 0, 60 kg P/ha
K 0, 1 = 0, 60 kg K/ha
Values are an average of 4 replications

Table 58. Nutrient concentration in whole plant samples. Sorghum experiment No.9, 1978

Treatment			Nutrient concentration in whole plant samples at harvest									Percent
N	P	K	N	P	K	Ca	Mg	Cu	Zn	Mn	Fe	IVOMD
			%					ppm				
0	0	0	0.66	0.31	1.32	0.20	0.20	13.5	475	78	192	56.48
0	0	1	0.64	0.31	1.62	0.16	0.16	12.0	465	69	120	58.44
0	1	0	0.55	0.28	1.55	0.16	0.15	13.7	477	68	95	57.18
0	1	1	0.65	0.33	1.55	0.15	0.16	14.2	475	67	427	57.68
1	0	0	0.79	0.30	1.59	0.14	0.21	17.2	460	44	82	55.50
1	0	1	0.78	0.30	1.62	0.16	0.19	15.2	462	51	82	56.31
1	1	0	0.83	0.28	1.36	0.16	0.22	13.7	475	50	85	54.90
1	1	1	0.83	0.29	1.45	0.16	0.22	12.5	485	49	85	55.68
2	0	0	1.13	0.35	1.46	0.20	0.26	14.0	480	46	72	55.04
2	0	1	1.00	0.30	1.78	0.16	0.23	13.7	480	43	77	57.25
2	1	0	1.04	0.32	1.27	0.21	0.29	14.2	465	53	127	54.64
2	1	1	1.01	0.35	1.55	0.16	0.24	13.7	472	51	80	56.25
3	0	0	1.26	0.33	1.59	0.18	0.24	14.0	470	42	82	56.39
3	0	1	1.15	0.29	1.57	0.16	0.19	13.7	465	42	80	59.12
3	1	0	1.20	0.41	1.50	0.23	0.30	15.5	417	64	82	56.84
3	1	1	1.18	0.35	1.60	0.16	0.23	14.0	317	43	77	58.15

1/ N 0, 1, 2, 3 = o, 100, 200, 300 kg N/ha
P 0, 1 = 0, 60 kg P/ha
K 0, 1 = 0, 60 kg K/ha
Values are an average of 4 replications

Table 59. Effect of N and P levels on K, Mg and Fe soil test at two levels of K. Sorghum experiment No.8, 1978

N	K = 0 kg/ha			K = 60 kg/ha		
	K	Mg	Fe	K	Mg	Fe
kg/ha	ppm					
0	33 a	68 a	44 a	53 a	70 a	45 a
100	28 ab	64 ab	45 a	32 b	65 ab	44 a
200	23 b	60 b	44 a	31 b	59 bc	44 a
300	23 b	51 c	43 a	28 b	51 c	42 a
P						
0	27 a	64 a	45 a	34 a	60 a	43 a
60	27 a	58 b	43 a	38 a	63 a	45 a

Means within each column for N or P treatments followed by different letters are significantly different according to Duncan's multiple range test.

Table 60. Effect of N and K levels on Mn soil test levels of P. Sorghum experiment No. 9, 1978

N	P = 0 kg/ha Mn	P = 60 kg/ha Mn
kg/ha	ppm	
0	2.70 c	2.95 a
100	2.85 bc	3.11 a
200	3.16 ab	2.75 a
300	3.32 a	2.92 a
K		
0	3.07 a	2.86 a
60	2.94 a	3.01 a

Means within each column for N or K treatments followed by different letters are significantly different according to Duncan's multiple range test.

Leaf nutrient concentrations response to levels of N, P, and K and their combinations are found in Tables 62 to 66. As expected addition of K fertilizer decreased P, Ca, and Mg concentration in the leaves but increased K concentration. Also, high N rates increased concentration of N, P, Mg and Mn at both 0 and 60 kg K/ha. At different combinations of P and K, the P concentration in the leaves increased going from the 0 to the 300 kg N/ha level.

Tables 67 and 69 present various NPK relationships for whole plant samples. It is evident that both N and K played an important role though their individual effects were almost opposite. Nitrogen increased N, P, and Mg concentrations and K decreased K, Ca, and Mg concentrations. Potassium increased the percent IVOMD (Table 68), contrary to what was found in experiment No. 6.

Correlation coefficients for soil and leaf nutrient concentrations as well as for grain and dry matter yields are presented in Table 70. Grain yield was positively correlated with N, P, Ca, and Mg concentration in the leaves; the R values were 0.85, 0.83, 0.73, and 0.73 respectively. Dry matter yield followed a similar pattern though R values were smaller.

Table 71 shows the nutrient content for all treatments. The amounts removed are smaller than those previously reported for a corn crop (Experiment No. 8). Nitrogen removal ranged from 18 to 55 kg/ha, P from 8 to 19 kg/ha, and K from 43 to 81 kg/ha. Assuming a N concentration in the grain of 1% (30), knowing that the amount of N removed in the whole plant was 55 kg N/ha, and the grain yield 3,958 kg/ha (treatment 300 N, 0 P, 60 K in Table 56), it is possible to calculate the amount of N recycled by this treatment.

Table 61. Effect of N levels on pH, Ca and Mg soil test and grain yield. Sorghum experiment No.9, 1978

N	pH	Ca	Mg	Grain yield
		----------ppm-------		kg/ha
0	5.74 a	672 a	69 a	1604 b
100	5.55 b	677 a	64 ab	3753 a
200	5.49 b	652 a	60 b	3858 a
300	5.23 c	605 b	51 c	3949 a

Means followed by different letters are significantly different according to Duncan's multiple range test. Comparisons should be made within columns.

Table 62. Effect of N levels on the concentration of several elements in the leaves. Sorghum experiment No.9, 1978

N	N	P	Ca	Mg	Cu	Zn	Mn	Fe
kg/ha	----------%----------				----------ppm----------			
0	1.38 c	0.36 d	0.19 b	0.18 b	11.69 b	124 b	44 c	72 b
100	2.45 b	0.56 c	0.30 a	0.39 a	14.31 a	132 b	56 ab	102 a
200	2.80 a	0.62 b	0.31 a	0.39 a	13.69 a	136 ab	52 b	111 a
300	2.91 a	0.67 a	0.32 a	0.40 a	14.75 a	146 a	60 a	106 a

Means followed by different letters are significantly different according to Duncan's multiple range test. Comparisons should be made within columns.

Table 63. Effect of K levels on the concentration of P, K, Ca, and Mg in the leaves. Sorghum experiment No.9, 1978

K	P	K	Ca	Mg
	----------%----------			
0	0.56 a	1.63 b	0.30 a	0.38 a
60	0.53 b	1.79 a	0.26 b	0.30 b

Means followed by different letters are significantly different according to Duncan's multiple range test. Comparisons should be made within columns.

Table 64. Effect of N levels on N, P, Mg, and Mn concentration in the leaves at 2 levels of K. Sorghum experiment No.9, 1978

N	K = 0 kg/ha				K = 60 kg/ha			
	N	P	Mg	Mn	N	P	Mg	Mn
kg/ha	----------%----------			ppm	----------%----------			ppm
0	1.35 c	0.36 d	0.19 b	43 b	1.41 d	0.35 c	0.17 b	45 b
100	2.47 b	0.57 c	0.43 a	60 a	2.42 c	0.54 b	0.34 a	51 ab
200	2.80 a	0.63 b	0.45 a	53 a	2.80 b	0.61 a	0.34 a	51 ab
300	2.84 a	0.69 a	0.45 a	61 a	2.97 a	0.64 a	0.35 a	59 a

Means followed by different letters are significantly different according to Duncan's multiple range test. Comparisons should be made within columns.

Table 65. Effect of N and K levels on P and Mn concentration in the leaves at 2 levels of P. Sorghum experiment No.9, 1978

N	P = 0 kg/ha		P = 60 kg/ha	
	P	Mn	P	Mn
kg/ha	%	ppm	%	ppm
0	0.35 c	43 c	0.37 c	45 b
100	0.54 b	52 b	0.57 b	59 a
200	0.64 a	53 ab	0.60 b	50 ab
300	0.67 a	61 a	0.66 a	59 a
K				
0	0.56 a	51 a	0.57 a	57 a
60	0.54 a	53 a	0.53 b	50 b

Means within each column for N or K treatments followed by different letters are significantly different according to Duncan's multiple range test.

Table 66. Effect of N levels on P concentration in the leaves at different combinations of P and K. Sorghum experiment No.9, 1978

N	kg/ha P_0 K_0	P_0 K_{60}	P_{60} K_0	P_{60} K_{60}
kg/ha	----------%P----------			
0	0.36 c	0.33 d	0.35 c	0.37 b
100	0.55 b	0.53 c	0.59 b	0.56 a
200	0.65 a	0.62 b	0.60 b	0.59 a
300	0.66 a	0.67 a	0.72 a	0.61 a

Means followed by different letters are significantly different according to Duncan's multiple range test. Comparisons should be made within columns.

Table 67. Effect of N levels on nutrient concentration of whole plant samples. Sorghum experiment No.9, 1978

N	N	P	Mg	Zn	Mn	Fe
kg/ha	----------%----------			----------ppm----------		
0	0.63 d	0.31 b	0.17 c	473 a	71 a	208 a
100	0.81 c	0.29 c	0.21 b	471 a	49 b	84 b
200	1.05 b	0.33 ab	0.26 a	474 a	49 b	89 b
300	1.20 a	0.35 a	0.24 a	417 b	48 b	81 b

Means followed by different letters are significantly different according to Duncan's multiple range test. Comparisons should be made within columns.

Table 68. Effect of K levels on K, Ca, and Mg concentration in whole plant samples, and on percent IVOMD. Sorghum experiment No.9, 1978

K	K	Ca	Mg	IVOMD
kg/ha	----------%----------			
0	1.46 b	0.19 a	0.24 a	55.87 b
60	1.59 a	0.16 b	0.20 b	57.36 a

Means followed by different letters are significantly different according to Duncan's multiple range test. Comparisons should be made within columns.

Table 69. Effect of N and K levels on P, Mg, and Zn concentration of whole plant samples at two levels of P. Sorghum experiment No.9, 1978

	P = 0 kg/ha			P = 60 kg/ha		
N	P	Mg	Zn	P	Mg	Zn
kg/ha	-----%-----		ppm	--------%--------		ppm
0	0.32 a	0.19 c	470 ab	0.31 bc	0.16 c	476 a
100	0.30 a	0.20 bc	461 b	0.29 c	0.22 b	480 a
200	0.32 a	0.25 a	480 a	0.38 ab	0.26 a	469 a
300	0.31 a	0.22 ab	467 ab	0.38 a	0.27 a	367 b
K						
0	0.33 a	0.23 a	471 a	0.33 a	0.24 a	459 a
60	0.30 a	0.19 b	468 a	0.33 a	0.21 a	437 a

Means within each column for N or K treatments followed by different letters are significantly different according to Duncan's multiple range test.

Table 70. Correlation coefficients for soil and leaf nutrient concentrations, grain, and dry matter yields. Sorghum experiments No.9, 1978

CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / N = 64

Leaf	PH	P	CA	MG	CU	ZN	MN	FE	GRAIN	DM
				Soil						
N	-0.57308 0.0001	-0.10614 0.4039	-0.71110 0.0040	-0.46781 0.0001	-0.05431 0.6700	-0.16402 0.1953	0.26002 0.0380	-0.05759 0.6513	0.65824 0.0001	0.45159 0.0002
P	-0.60611 0.0001	-0.09143 0.4724	-0.19766 0.1174	-0.48486 0.0001	-0.02603 0.8382	-0.14773 0.2440	0.10845 0.0111	-0.06541 0.6076	0.43389 0.0001	0.44528 0.0002
K	-0.23241 0.0646	0.01242 0.9193	0.04705 0.7130	-0.11869 0.3502	-0.03331 0.7957	0.24571 0.0503	0.12251 0.3149	0.23279 0.0642	0.16664 0.1882	0.13223 0.2976
Ca	-0.42680 0.0004	-0.02794 0.8265	-0.06497 0.6100	-0.11764 0.3505	0.03832 0.7637	-0.06796 0.5936	0.24196 0.0541	-0.02114 0.8681	0.73356 0.0001	0.43641 0.0003
Mg	-0.46950 0.0001	-0.04951 0.6976	-0.12181 0.3176	-0.34973 0.0046	-0.04148 0.7449	-0.20881 0.0977	0.20949 0.0966	-0.08750 0.4918	0.73521 0.0001	0.36212 0.0033
Cu	-0.11755 0.3549	-0.07384 0.5620	0.22892 0.0688	0.05890 0.6439	0.26077 0.0374	0.30390 0.0146	0.35877 0.0036	0.09254 0.4670	0.43833 0.0003	0.32448 0.0089
Zn	-0.27681 0.0268	0.08172 0.5209	-0.03046 0.8112	-0.05448 0.6690	0.24855 0.0477	-0.08639 0.4973	0.24123 0.0548	-0.10444 0.4144	0.28949 0.0203	0.44507 0.0002
Mn	-0.39042 0.0014	-0.07445 0.5588	-0.05199 0.6833	-0.25740 0.0400	0.21513 0.0878	0.11538 0.3639	0.31546 0.0111	-0.07751 0.5427	0.43530 0.0003	0.49004 0.0001
Fe	-0.28617 0.0219	-0.11452 0.3676	-0.14075 0.2673	-0.17581 0.1647	-0.00182 0.9204	-0.23292 0.0640	-0.07844 0.5378	-0.08961 0.4813	0.35855 0.0036	0.16601 0.1898
Grain	-0.44414 0.0002	-0.07103 0.5770	-0.06741 0.5966	-0.34560 0.0052	-0.02885 0.8210	-0.00955 0.9403	0.24799 0.0482	-0.04281 0.7370	1.00000 0.0000	0.53010 0.0001
DM	-0.18772 0.1374	0.22603 0.0725	0.20208 0.1093	0.00760 0.9524	0.12371 0.3301	0.24208 0.0539	0.17216 0.1717	-0.14798 0.2432	0.53010 0.0001	1.00000 0.0001

Table 71. Nutrient content in kg/ha. Sorghum fertility experiment No.9, 1978

Treatment 1/			kg/ha at harvest							
N	P	K	N	P	K	Ca	Mg	Cu	Zn	Mn	Fe
0	0	0	22.0	10.4	43.1	6.82	6.81	0.04	1.57	0.26	0.65
0	0	1	18.1	8.9	45.8	4.81	4.62	0.03	1.32	0.20	0.34
0	1	0	18.1	9.2	50.8	5.30	5.10	0.04	1.55	0.22	0.30
0	1	1	24.5	12.3	58.1	5.77	6.09	0.05	1.77	0.25	1.40
1	0	0	34.4	13.0	68.8	6.33	9.10	0.07	2.01	0.19	0.35
1	0	1	34.8	13.5	71.5	7.27	8.81	0.07	2.12	0.22	0.37
1	1	1	35.3	11.7	57.6	6.94	9.25	0.05	1.98	0.21	0.35
1	1	1	39.2	13.5	68.9	7.57	10.24	0.06	2.30	0.23	0.39
2	0	0	48.4	15.4	63.7	8.56	11.42	0.06	2.17	0.20	0.32
2	0	1	43.7	13.1	81.5	7.19	10.13	0.06	2.20	0.19	0.33
2	1	0	44.9	13.7	54.7	9.06	11.88	0.05	2.10	0.23	0.57
2	1	1	46.6	16.2	69.3	7.41	10.85	0.06	2.23	0.23	0.37
3	0	0	36.9	9.9	45.8	5.29	7.18	0.03	1.37	0.12	0.24
3	0	1	46.5	11.8	63.4	6.45	7.73	0.05	1.93	0.16	0.33
3	1	0	55.5	19.5	68.5	10.56	14.36	0.07	2.02	0.30	0.37
3	1	1	52.3	15.5	71.0	7.28	10.0	0.06	1.50	0.19	0.34

1/ N 0, 1, 2, 3 = 0, 100, 200, 300 kg/ha
P 0, 1 = 0, 60 kg/ha
K 0, 1 = 0, 60 kg/ha
Values are an average of 4 replications

3,958 x 0.01 = 39.58 kg N/ha in the grain

55.00 - 39.58 = 15.42 kg N/ha returned to the soil

Likewise since out of 300 kg N/ ha applied to the soil only 55 kg/ha was removed by the whole plant (forage and grain), this represents an 18% removal of N in relation to N applied, a low figure indeed.

Correlation coefficients for soil test and whole plant nutrient concentration, nutrient content, grain, and dry matter yields are presented in Table 72. Nitrogen concentration in whole plant samples was negatively correlated with K and Mg in the soil but positively correlated with grain (R = 0.69) and dry matter yield (R = 0.29). However, nutrient content in whole plant samples was positively correlated only with grain and dry matter yields (R = 0.71 and R = 0.79, respectively). The high R values in this latter case suggest that N content in whole plant samples could be a good indicator of yield potential for sorghum. Table 73 shows the same kind of relationships using nutrient concentration values in the leaves (instead of nutrient concentration in the soil). In this case N in whole plant samples was positively correlated with N, P, Ca, Mg, Ca, Zn, Mn, and Fe in the leaves as well as with grain yield and dry matter. Very high R values up to 0.83 indicate that leaf concentration could aslo be a good indicator of the sorghum fertility status and yield. Nitrogen content in whole plant samples showed, except for Fe, the same positive correlation found in the leaf samples, suggesting that they could be used interchangeably.

Despite differences due to management, crop and location, there appears to be some general trends derived from all fertility experiments during 1977 and 1978. Nitrogen was definitely the most important element

Table 72. Correlation coefficients for soil and whole plant nutrient concentrations, and nutrient content, grain, DM, and percent IVOMD. Sorghum fertility experiment No.9, 1978

CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO = 0 / N = 64

Nutrient conc.	P1	P	K	CA	MG	CU	ZN	MN	FE	GRAIN	DM
					Soil						
N	-0.06408 0.6091	-0.12779 0.3162	-0.37222 0.0025	-0.23520 0.0619	-0.43911 0.0003	0.05841 0.6466	-0.11115 0.3820	0.19601 0.1201	-0.04122 0.7865	0.65246 0.0001	0.29171 0.0195
P	-0.25038 0.0459	0.06122 0.6308	0.03199 0.8019	0.01976 0.8774	-0.11034 0.3854	0.14009 0.2696	0.05886 0.6608	0.02901 0.8200	0.01691 0.8935	0.20794 0.0972	0.29300 0.0185
K	-0.08607 0.4985	0.18381 0.1460	0.14002 0.2676	0.05702 0.6545	-0.03255 0.7995	-0.02979 0.8152	0.13213 0.2980	-0.09359 0.4672	0.00954 0.9406	0.04374 0.7003	0.14609 0.2494
Ca	-0.03674 0.7769	-0.02137 0.8669	-0.07764 0.5420	-0.04107 0.7473	-0.10015 0.4311	0.03309 0.7951	-0.10135 0.4255	-0.10495 0.4108	-0.14650 0.2480	0.10994 0.3915	0.11741 0.3657
Mg	-0.32795 0.0082	-0.09034 0.4777	-0.44483 0.0002	-0.17923 0.1585	-0.27121 0.0302	-0.05194 0.6778	-0.30179 0.0154	0.03837 0.7814	-0.16272 0.1903	0.48825 0.0001	0.21352 0.0603
Cu	-0.10135 0.4255	0.15873 0.2103	-0.15455 0.2227	-0.21422 0.0892	-0.14357 0.2577	0.31092 0.0131	-0.33810 0.0104	-0.09696 0.4459	-0.17936 0.1657	0.07426 0.5598	0.17553 0.1653
Zn	0.19759 0.1178	0.00846 0.9471	0.20510 0.1040	0.26012 0.0378	0.32662 0.0084	0.17724 0.1665	0.37466 0.0020	0.28453 0.0235	-0.32836 0.0081	0.19543 0.1208	0.27632 0.0271
Mg	0.23463 0.0626	-0.04105 0.7474	0.44500 0.0002	0.11101 0.3825	0.16496 0.1927	0.09560 0.4524	0.21367 0.0900	-0.13138 0.2334	-0.14281 0.2603	-0.38550 0.0017	0.01946 0.8781
Fe	0.28596 0.0220	0.16937 0.1809	0.26861 0.0319	0.15310 0.2271	0.15701 0.2153	0.03350 0.7937	0.04356 0.7325	-0.10661 0.4018	0.08483 0.5051	-0.37293 0.0024	-0.16994 0.1797
Grain	-0.44414 0.0002	-0.07103 0.5770	-0.50149 0.0001	-0.06741 0.5966	-0.34560 0.0052	-0.02085 0.8210	-0.00955 0.9403	0.24799 0.0482	-0.04201 0.7370	1.00000 0.0000	0.53010 0.0001
DM	0.18772 0.1374	0.32603 0.0725	-0.05834 0.6470	0.20200 0.1093	0.00760 0.9524	0.12371 0.3301	0.24208 0.0539	0.17216 0.1717	-0.14799 0.2432	0.53010 0.0001	1.00000 0.0001
IVGMD	-0.23168 0.0655	-0.10987 0.3874	0.29911 0.0164	-0.16043 0.2054	-0.11949 0.3470	0.08376 0.5105	0.21443 0.0889	0.10394 0.4137	-0.09871 0.4377	-0.12002 0.3449	0.01132 0.9292
Content											
N	-0.47478 0.0001	0.04253 0.7386	-0.25693 0.0404	-0.04756 0.7090	-0.26786 0.0334	0.12497 0.3251	0.06720 0.5869	0.21345 0.0898	-0.11074 0.3837	0.70736 0.0001	0.74150 0.0001
P	-0.26754 0.0326	0.17606 0.1640	-0.03913 0.7589	0.11584 0.3845	-0.05586 0.6611	0.17371 0.1698	0.17789 0.1596	0.11761 0.3547	-0.10117 0.4264	0.44486 0.0001	0.48627 0.0001
K	-0.17099 0.1767	0.26400 0.0350	0.03446 0.7869	0.10355 0.4165	0.00817 0.9477	0.06256 0.6189	0.23697 0.0594	0.12267 0.3342	-0.09501 0.4552	0.44528 0.0002	0.46022 0.0001
Ca	-0.14718 0.2468	0.15056 0.2367	-0.07358 0.5571	0.11656 0.3570	-0.04439 0.7276	0.13206 0.2983	0.06750 0.6017	0.06276 0.6276	-0.18203 0.1500	0.39749 0.0011	0.47541 0.0001
Mg	-0.11111 0.0124	0.10089 0.4935	-0.29923 0.0177	0.01696 0.8942	-0.16017 0.2061	0.07495 0.5561	-0.05534 0.6641	0.11319 0.3861	-0.19113 0.1303	0.49008 0.0001	0.47505 0.0001
Cu	-0.12051 0.1535	0.26766 0.0325	-0.12297 0.3329	-0.01003 0.9373	-0.08655 0.4965	0.14885 0.2404	-0.08963 0.4812	0.03202 0.8017	-0.17886 0.1573	0.34959 0.0046	0.41881 0.0001
Zn	0.07431 0.5595	0.09440 0.4961	0.10958 0.4019	0.29479 0.0180	0.25760 0.0398	0.18965 0.1334	0.40746 0.0008	0.20093 0.9245	-0.29921 0.0163	0.49279 0.0010	0.42134 0.0001
Mn	0.04495 0.7245	0.10418 0.4126	0.30226 0.0152	0.20356 0.1062	0.13003 0.3054	0.15291 0.2339	0.27661 0.0269	0.02135 0.8570	-0.27102 0.1112	0.01643 0.8962	0.07658 0.5001
Fe	0.24483 0.0512	0.20425 0.1065	0.25174 0.0441	0.12362 0.4251	0.13513 0.2790	0.06619 0.6076	0.09766 0.4458	0.04896 0.6936	0.06005 0.6371	-0.25591 0.0420	0.03316 0.7918

Table 73. Correlation coefficients for leaf and whole plant nutrient concentrations and nutrient content, grain, DM, and percent IVOMD. Sorghum fertility experiment No.9, 1978

CORRELATION COEFFICIENTS / PROB > |R| UNDER HYPOTHESIS / N = 64

Nutrient conc.	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11
						Leaf					
N	0.93956 0.0001	0.93645 0.0001	0.13168 0.2923	0.66087 0.0001	0.58697 0.0001	0.18505 0.0017	0.36753 0.0028	0.44441 0.0002	0.70147 0.0019	0.69246 0.0001	0.79171 0.0195
P	0.70058 0.0158	0.73226 0.0003	0.05639 0.6581	0.25405 0.0428	0.11764 0.3545	0.26144 0.0154	0.22584 0.0176	0.26417 0.0132	0.11971 0.3460	0.20734 0.0992	0.29140 0.0135
K	0.12400 0.3289	0.06501 0.6098	0.31372 0.0116	-0.11107 0.3825	-0.19455 0.1234	-0.04406 0.7296	0.00194 0.9878	0.13397 0.2912	-0.10443 0.4137	0.09384 0.4603	0.13698 0.3434
Ca	0.11301 0.3655	0.13454 0.2945	-0.12154 0.3397	0.26553 0.0333	0.23521 0.0613	0.05724 0.6446	0.27802 0.0264	0.12669 0.3185	0.06211 0.6259	0.10894 0.3915	0.13741 0.3157
Mg	0.95918 0.0001	0.94124 0.0001	-0.23089 0.0664	0.58264 0.0001	0.46995 0.0001	0.02524 0.8431	0.37050 0.0026	0.43550 0.1321	0.70098 0.0001	0.68525 0.0001	0.73152 0.0633
Cu	0.02009 0.8748	0.06533 0.6035	-0.22843 0.0695	0.12111 0.3436	0.16180 0.2015	-0.17099 0.0025	0.32235 0.0094	0.09643 0.4485	-0.01324 0.9171	0.07426 0.5908	0.17553 0.1653
Zn	0.00057 0.9964	0.01740 0.8915	-0.04760 0.7008	0.06452 0.6125	-0.01997 0.8756	0.52372 0.0001	0.36407 0.0031	0.29705 0.0171	-0.17691 0.1609	0.19593 0.1208	0.27626 0.0271
Mn	-0.45912 0.0001	-0.43108 0.0019	0.02286 0.8577	-0.32463 0.0089	-0.10959 0.3808	0.21352 0.0901	0.05698 0.6547	0.13096 0.3027	-0.45677 0.0001	-0.38550 0.0017	0.01956 0.8701
Fe	-0.35646 0.0037	-0.34692 0.0050	0.05199 0.6833	-0.11125 0.4121	-0.12402 0.3330	-0.00015 0.9989	-0.12558 0.3228	-0.26240 0.0362	-0.19981 0.1113	-0.17293 0.0034	-0.12304 0.1737
Grain	0.85824 0.0001	0.83399 0.0001	0.16664 0.1892	0.73356 0.0001	0.73521 0.0001	0.43813 0.0003	0.28949 0.0203	0.43530 0.0003	0.35855 0.0036	1.00000 0.0000	0.63010 0.0001
DM	0.95155 0.0002	0.94528 0.0002	0.13223 0.2976	0.63641 0.0003	0.56212 0.0031	0.32448 0.0083	0.44507 0.0002	0.49004 0.0001	0.66601 0.1098	0.63010 0.0001	1.00000 0.0001
IVOMD	0.00796 0.9507	-0.04950 0.7015	0.29473 0.0181	-0.19141 0.1514	-0.23338 0.0731	0.18235 0.1435	0.03337 0.7935	0.23530 0.0612	-0.22303 0.0765	-0.12002 0.3449	0.01132 0.9292
Content											
N	0.76238 0.0001	0.75776 0.0001	0.12110 0.3141	0.65389 0.0001	0.53852 0.0001	0.41844 0.0006	0.51885 0.0001	0.55878 0.0001	0.32149 0.0076	0.73736 0.0001	0.79130 0.0001
P	0.46240 0.0091	0.49925 0.0001	0.09055 0.4767	0.45089 0.0002	0.12386 0.4098	0.34768 0.0043	0.48808 0.0001	0.57012 0.0001	0.12150 0.4295	0.46499 0.0001	0.61627 0.1001
K	0.41208 0.0007	0.38185 0.0017	0.26042 0.0477	0.29307 0.0219	0.19930 0.1162	0.22125 0.0795	0.14937 0.2847	0.41137 0.0004	0.05004 0.6941	0.44528 0.0002	0.86022 0.0001
Ca	0.31257 0.0032	0.32772 0.0004	-0.01330 0.9169	0.45235 0.0002	0.37466 0.0023	0.25003 0.0451	0.49613 0.0001	0.49370 0.0015	0.15945 0.2801	0.35739 0.0011	0.74581 0.0001
Mg	0.96110 0.0001	0.95550 0.0001	-0.09707 0.4939	0.61491 0.0001	0.60753 0.0001	0.19553 0.1215	0.53560 0.0001	0.38623 0.0016	0.80619 0.0002	0.59008 0.0001	0.76595 0.0001
Cu	0.26776 0.0324	0.23178 0.0145	-0.06405 0.6077	0.13195 0.3074	0.11526 0.3687	-0.16100 0.2030	0.08050 0.5001	0.15246 0.2343	0.08969 0.5012	0.13455 0.3046	0.71081 0.0001
Zn	0.27228 0.0299	0.22179 0.0779	0.02432 0.8447	0.23337 0.0635	0.14578 0.2437	0.56759 0.0001	0.43243 0.0003	0.49537 0.0009	-0.06795 0.5901	0.49279 0.0010	0.62134 0.0001
Mg	-0.08625 0.4977	-0.01843 0.8851	0.06901 0.5879	0.01875 0.8841	-0.01987 0.8761	0.16495 0.1909	0.11478 0.3618	0.17630 0.1922	-0.25855 0.0434	0.01664 0.8962	0.57658 0.0001
Fe	-0.26284 0.0350	-0.25804 0.0395	0.07761 0.5431	-0.21365 0.0900	-0.13726 0.2840	-0.03275 0.7967	-0.02813 0.8260	-0.31182 0.1014	-0.16655 0.1945	-0.25501 0.0426	0.03116 0.7948

affecting not only grain and dry matter yields but also nutrient relationships in all collected samples. In all cases the first N increment was sufficient to maximize yields, higher rates causing either a slight decrease or no increase at all. However, this conclusion is especially valid for the management level presently used by local farmers. Improvements in irrigation, weed control, and plant population management would likely result in a need for higher N rates in order to obtain higher yields. This is confirmed by other research (48). Economic considerations would certainly play an important role in decision making. For 1977 conditions, Dilbeck[1/] estimated a net income of $223.8 and $98.5/ha for corn and sorghum respectively following cabbage and potato crops. These figures seem attractive considering that land, equipment, and solar energy are plentiful in the area during the summer months. The fertility research reported here showed that high N rates caused a drop in pH and extractable nutrients in the soil, and an increase in N, Ca, Mg, Zn, and Mn in the leaves, and whole plant samples.

Phosphorus and K tended to decrease grain and dry matter yields in several cases, suggesting salinity problems and possibly nutrient toxicity. The previous well fertilized vegetable crop would certainly contribute to the problem. Potassium showed ion antagonism and reciprocal relationships normally found in these type of studies (47). In several cases fertilizer K decreased Mg concentration and content in plant samples, similar results occurred with N, P, and Ca. Potassium was the only nutrient affecting percent IVOMD. However, the trend was not clear since in one study it increased percent IVOMD, and in another it caused a

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1/ Dilbeck, J. 1977. Annual Grain Meeting. St. Johns Country Fairgrounds, Feb. 28, 1977.

significant decrease. Magnesium and Mn showed good correlation with other elements. For instance it was found that Mg in the leaves was negatively correlated with K, Ca, Mg, and Zn concentrations in the soil in several cases. In general it was observed that plant samples showed more significant differences than soil samples and that the use of correlations provided a good insight in nutrient balance and relationships.

Bedding Experiments

The main idea behind modifications of the traditional 1 m wide potato beds was to provide better use of space for the sorghum crop. The objectives of the bedding experiments were met fully because of good overall management during both years. Soil test were made prior to planting each year. Data are presented in Tables 74 and 75.

Differences in agronomic variables as determined by the F test are shown in Tables 76 and 77. The type of bed and the modifications imposed on them influenced yield. All treatments that provided narrower rows (except broadcast) than the 1 m bed single row check resulted in increased grain yield (Table 78). Highest yield was from the 2.0 m bed three or four row treatments. Grain yield for these treatments were 3,323 and 3,335 kg/ha respectively, a 40% yield advantage over the control. This would be a relatively easy treatment for which present equipment could be adapted. One meter bedding equipment could be converted to 2.0 m bedding equipment with relative ease by removing every other bedder. The highest yielding 2.0 m beds three row treatment would be difficult to cultivate without modifying existing equipment. On the other hand narrow rows helped to suppress weed growth by competition and shadening, provided the weeds could be controlled during early sorghum growth with herbicides.

Table 74. Soil analysis before planting. Sorghum bedding experiment No.6, 1977

Rep	pH	P	K	Ca	Mg	Cu	Zn	Mn	Fe
		ppm							
I	5.1	280	96	758	57	4.60	9.1	5.8	67
II	5.0	383	112	906	60	5.64	11.3	6.8	70
III	4.9	312	109	858	60	5.36	9.6	5.7	69
IV	4.9	351	98	796	55	4.12	8.4	5.7	60
$\bar{X}$		331	104	829	58	4.93	9.6	6.0	66

Table 75. Soil analysis before planting. Bedding experiment No.10, 1978

Rep	pH	P	K	Ca	Mg	Cu	Zn	Mn	Fe
		ppm							
I	5.5	248	94	724	96	4.8	11	4.4	56
II	5.4	274	84	716	92	6.8	13	4.8	52
III	5.2	293	76	752	84	6.0	12	4.4	48
IV	5.2	300	92	688	88	4.4	10	4.0	44
$\bar{X}$		279	86	720	90	5.5	11	4.4	50

Table 76. Significant variables as determined by F test. Combined analysis 1977 and 1978. Bedding experiment No.6 and 10

Source	Dry matter yield	Grain yield	Plant population	Plant height
Rep				
Bed	0.0377	0.0031	0.0001	
Rep c Bed				
Arr (bed)	0.0001	0.0001	0.0001	0.0025
Rep x Arr (bed)				
Year	0.0001		0.0270	0.0001
Bed x Year	0.0001	0.0001	0.0001	0.0097
Arr x Year (bed)			0.0001	

Table 77. Significant variables as determined by the F test, 1977 and 1978. Bedding experiments No.6 and 10

Source	Dry matter yield		Grain yield		Plant population		Plant height	
	1977	1978	1977	1978	1977	1978	1977	1978
Rep								
Bed	0.0169		0.0053	0.0037	0.0028	0.0001		
Rep x Bed								
Arr (bed)	0.0017	0.0016		0.0001	0.0001	0.0001	0.0247	0.0016

Table 78. Grain yield in kg/ha. Bedding experiments No. 6 and 10, 1977 and 1978.

Treatment		1977	1978	Average
		kg/ha		
I	1	2389 bc	2443 bcd	2416 b
	2	2436 bc	3125 a	2781 a
	3	3155 a	3008 ab	3081 a
	4	2433 bc	2188 d	2311 b
	5	2046 c	2201 d	2123 b
	6	2832 ab	2824 abc	2833 a
	7	2139 c	2352 cd	2246 b
II	8	3300 a	2983 a	3142 a
	9	3062 a	2572 ab	2817 a
	10	3092 a	2032 b	2562 a
	11	3195 a	2352 b	2768 a
III	12	2713 a	3934 a	3323 a
	13	2793 a	3877 a	3335 a
	14	2714 a	3156 b	2935 ab
	15	2622 a	2700 c	2661 b
	16	2482 a	3159 b	2821 b

I, II, III = 1.0, 1.5 and 2.0 m beds respectively.
Means followed by different letters within each bed group are significantly different according to Duncan's multiple range test.
Comparisons should be made within columns.

The 1.5 m beds showed a slight advantage over 1.0 m beds planted to twin double wide rows per bed. However, it would be harder to adapt 1.0 m bedding equipment for 1.5 m beds.

Running very close to the 2.0 m bed three or four row treatments was the 1.0 m bed double wide two rows per bed. This treatment gave 29% higher grain yield than the 1.0 m bed one row check. Existing 25 cm cultivator weed control equipment could easily be used with the 1.0 m bed double wide row treatment. The increased plant population from double rows would make better use of available space, water, and fertilizer and provide better shading of weeds. In all cases broadcast treatment had inferior yields within each type of bed.

Dry matter yields (Table 79) followed a similar pattern to grain yield, 2.0 m and 1.5 m beds in general outyielded 1.0 m beds except for the double narrow and double wide two rows treatments. The best treatment was the 2.0 m five rows with 12,518 kg/ha, this represents a 44% increase over the 1.0 m bed one row treatment.

The resulting plant population according to the bed modifications imposed appear in Table 80. There is a close association between the highest yielding treatments and their plant population. The 1.5 and 2.0 m beds with the largest number of rows also had the largest populations. Plant height did not change appreciably.

Significant effects on whole plant analysis appear in Tables 81 and 82 for both years and for each year separately. The percent IVOMD was not different from either bed type or for arrangements within beds.

Nutrient concentrations and percent IVOMD for 1977, 1978 and the average for both years are shown in Tables 83, 84, and 85. The differences

Table 79. Dry matter yield in kg/ha. Bedding experiments No. 6 and 10, 1977 and 1978.

Treatment		1977	1978	Average
		kg/ha		
I	1	9342 d	8021 b	8681 e
	2	11706 bc	9962 a	10834 abc
	3	13046 ab	9349 ab	11197 ab
	4	10568 cd	7903 b	9236 de
	5	11222 bc	7807 b	9514 cde
	6	14314 a	9805 a	12060 a
	7	12077 bc	8473 ab	10275 bcd
II	8	14552 a	9045 a	11798 a
	9	13277 a	9263 a	11270 a
	10	15569 a	9052 a	12310 a
	11	13621 a	7265 b	10443 a
III	12	11351 a	10193 a	10772 a
	13	13438 a	10136 a	11787 a
	14	14548 a	10488 a	12518 a
	15	13422 a	9756 a	11589 a
	16	11904 a	8057 b	9980 a

I, II, III = 1.0, 1.5 and 2.0 m beds, respectively.
Means followed by different letters within each bed group are significantly different according to Duncan's multiple range test.
Comparisons should be made within columns.

Table 80. Average plant population and plant height for 1977 and 1978. Bedding experiment No. 6 and 10.

Treatment		Pt. Pop. pts/ha 1000	Pt. Ht. cm
I	1	112 c	158 a
	2	230 a	158 a
	3	230 a	156 a
	4	135 c	146 b
	5	115 c	159 a
	6	247 a	159 a
	7	200 b	157 a
II	8	300 ab	157 c
	9	367 ab	156 b
	10	417 a	162 a
	11	217 b	151 d
III	12	288 b	156 a
	13	364 a	157 a
	14	406 a	158 a
	15	408 a	157 a
	16	244 b	155 a

I, II, III = 1.0, 1.5 and 2.0 m beds respectively. Means followed by different letters within each bed group are significantly different according to Duncan's multiple range test.

Table 81. Significant variables as determined by the F test. Combined analysis 1977 and 1978 . Bedding experiments No.6 and 10

Source	D.F	N	P	K	Ca	Mg	Cu	Zn	Mn	Fe	IVOMD
		F-test on whole plant nutrient concentration and percent IVOMD									
Rep	3										
Bed	2								0.0495		
Bed x Rep	6										
Arr (bed)	13										
Arr x Bed (bed)	39										
Yr	1	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	
Yr x Bed	2										
Yr x Arr (bed)	13										

Table 82 Significant variables as determined by the F test. Bedding experiments No.6 and 10.

Source	D.F	N	P	K	Ca	Mg	Ca	Z n	Mn	Fe	IVOMD
					F-test on whole plant nutrient concentration and percent IVOMD						
						1977					
Rep	3										
Bed	2									0.0387	
Bed x Rep	6										
Arr (bed)	13										0.0207
						1978					
Rep	3										
Bed	2							0.0236	0.0122		
Bed x Rep	6										
Arr (bed)	13					0.0367					

Table 83. Nutrient concentration and percent IVOMD for whole plant samples. Bedding experiment No. 6, 1977.

Treatment		Nutrient concentration in whole plant samples at harvest									IVOMD
		N	P	K	Ca	Mg	Cu	Zn	Mn	Fe	
		%					ppm				%
I	1	1.10	0.35	1.74	0.21	0.16	12.0	247	65.00	62	57.52 ab
	2	0.85	0.31	1.55	0.22	0.15	15.7	250	72.75	75	57.46 ab
	3	0.92	0.33	1.61	0.20	0.15	12.2	225	70.50	60	56.51 ab
	4	1.01	0.30	1.69	0.20	0.15	13.5	227	68.00	65	59.32 a
	5	0.94	0.32	1.50	0.21	0.14	15.7	275	65.50	62	59.29 a
	6	1.06	0.34	1.72	0.24	0.17	17.2	247	67.75	75	52.23 b
	7	0.90	0.30	1.54	0.19	0.14	17.5	237	61.25	50	58.29 a
II	8	1.12	0.38	1.95	0.23	0.17	17.5	240	60.75	77	51.94 b
	9	1.16	0.35	1.92	0.22	0.17	15.2	240	62.75	62	55.58 ab
	10	1.01	0.35	1.55	0.21	0.16	13.5	247	54.75	70	56.45 ab
	11	1.30	0.37	1.84	0.24	0.17	14.2	250	68.50	80	58.88 a
III	12	1.43	0.38	1.84	0.21	0.17	13.7	242	65.25	75	59.77 a
	13	1.21	0.35	1.84	0.23	0.17	14.2	282	56.25	85	53.92 b
	14	0.89	0.33	1.69	0.22	0.16	13.5	277	67.25	65	54.11 b
	15	1.02	0.33	1.65	0.21	0.16	13.7	272	53.25	67	57.24 ab
	16	1.14	0.36	1.81	0.23	0118	17.0	295	62.75	110	57.04 ab

I, II, III = 1.0, 1.5, and 2.0 m beds respectively.
Means followed by different letters within each bed group significantly different according to Duncan's multiple range test.

Table 84. Nutrient concentration and percent IVOMD for whole plant samples. Bedding experiment No.10, 1978

Treatment	Nutrient concentration in whole plant samples at harvest									IVOMD
	N	P	K	Ca	Mg	Cu	Zn	Mn	Fe	
	%					ppm				%
I 1	0.57	0.25	1.68	0.16	0.19 ab	10.2	93	47	75	54.40
2	0.68	0.32	1.73	0.18	0.22 a	11.5	97	57	95	58.76
3	0.67	0.27	1.42	0.22	0.21 ab	10.7	86	60	95	56.04
4	0.64	0.26	1.39	0.18	0.18 ab	11.0	77	64	70	57.36
5	0.67	0.24	1.38	0.16	0.16 b	10.0	84	51	90	57.70
6	0.62	0.23	1.46	0.16	0.16 b	11.0	88	44	80	55.00
7	0.62	0.27	1.61	0.18	0.18 ab	10.2	94	50	82	56.27
II 8	0.69	0.29	1.78	0.16	0.18 b	10.0	87	47	77	57.16
9	0.74	0.28	1.59	0.21	0.20 ab	10.5	89	50	95	56.91
10	0.84	0.31	1.50	0.24	0.23 a	11.2	98	50	90	55.31
11	0.76	0.29	1.52	0.18	0.20 ab	10.2	89	50	80	58.67
III 12	0.71	0.24	1.62	0.14	0.17 b	11.0	89	35	70	55.61
13	0.71	0.25	1.37	0.17	0.19 ab	11.2	96	42	70	54.22
14	0.69	0.24	1.48	0.21	0.22 a	10.5	99	43	77	53.81
15	0.72	0.29	1.49	0.18	0.19 ab	10.5	100	51	72	56.41
16	0.78	0.34	1.44	0.19	0.22 a	11.5	109	55	105	59.78

I, II, II = 1.0, 1.5, and 2.0 m beds respectively
Means followed by different letters within each bed group are significantly different according to Duncan's multiple range test.

Table 85. Nutrient concentration and percent IVOMD for whole plant samples. Combined analysis 1977, 1978. Bedding experiments No.6 and 10

Treatment	Nutrient concentration in whole plant samples									IVOMD
	N	P	K	Ca	Mg	Cu	Zn	Mn	Fe	
			%				ppm			-- % --
I										
1	0.83	0.30	1.71	0.18	0.178	11.1	170	56	68	55.96
2	0.77	0.31	1.64	0.20	0.192	13.6	173	65	85	58.11
3	0.79	0.30	1.51	0.21	0.186	11.5	155	65	77	56.27
4	0.83	0.28	1.54	0.19	0.170	12.2	152	66	67	58.34
5	0.81	0.28	1.44	0.18	0.155	12.8	179	58	76	58.50
6	0.84	0.28	1.59	0.20	0.168	14.1	167	56	77	53.62
7	0.76	0.29	1.57	0.19	0.165	13.8	166	56	66	57.28
II										
8	0.90	0.33	1.86	0.20	0.181	13.7	163	54	77	54.55
9	0.95	0.32	1.75	0.22	0.186	12.8	164	56	78	56.24
10	0.92	0.33	1.53	0.22	0.198	12.3	172	52	80	55.88
11	1.03	0.33	1.68	0.21	0.188	12.2	169	59	80	58.77
III										
12	1.07	0.31	1.73	0.17	0.172	12.3	165	50	72	57.69
13	0.96	0.30	1.61	0.20	0.185	12.7	189	49	77	54.07
14	0.79	0.29	1.59	0.22	0.195	12.0	188	55	71	53.96
15	0.87	0.31	1.57	0.19	0.181	12.1	186	52	70	56.82
16	0.96	0.35	1.63	0.21	0.202	14.2	202	59	107	58.41

I, II, III = 1.0, 1.5, and 2.0 m beds respectively

in nutrient concentration between years are striking and could possibly be attributed to a number of causes, namely nutrient dilution and environmental conditions affecting the state of the tissue at sampling time. As expected, difference in concentration would also affect nutrient content values. In Tables 86 and 87 it is observed that 1978 presented much lower nutrient content values than 1977. Highest N content was 175 kg/ha in 1977 for the 1.5 m broadcast treatment as opposed to 76 kg N/ha in 1978 for 1.5 m five rows treatment. Phosphorus content ranged from 32 to 55 kg/ha in 1977 and from 21 to 28 kg/ha in 1978. Potassium content also showed appreciable differences ranging from 163 to 284 kg K/ha in 1977 and from 110 to 174 kg K/ha in 1978. Since only 75 kg N/ha were added to the crop, N depletion from the soil was very high in 1977. In other words 233% N was removed in relation to N applied in the 1.5 m bed broadcast treatment as compared to 101% for the 1.5 m five rows treatment in 1978.

Correlation coefficients for nutrient samples, agronomic variables, and nutrient content in whole plant samples are presented in Tables 88 and 89 for 1977 and 1978, respectively. Percent IVOMD was negatively correlated with plant population, dry matter yield, and P, K, Ca, Mg, Cu, and Zn content in whole plant samples during 1977. However, the R values were low ranging from 0.29 to 0.43, indicating a weak correlation. In 1978 the percent IVOMD was also negatively correlated with P and Ca content in whole plant samples. Grain yield, plant population and plant height did not show any correlations with nutrient concentration in whole plant samples. As could be expected, nutrient concentration and nutrient content of N, P, K, Ca, and Mg presented a close degree of correlation for both years. This is also shown in Table 90 when a combined analysis was conducted.

Table 86. Nutrient content of whole plant samples. Bedding experiments No.6 and 10, 1977 and 1978. At harvest.

Treatment	N	P	K	Ca	Mg	Cu	Zn	Mn	Fe
					kg/ha				
I					1977				
1	104	33	163	19	15	0.11	2.31	0.61	0.59
2	101	36	183	25	18	0.18	2.96	0.85	0.87
2	120	43	212	27	20	0.16	2.94	0.92	0.78
4	105	31	177	21	16	0.14	2.39	0.71	0.68
5	105	36	168	23	16	0.17	3.09	0.73	0.70
6	152	49	247	34	24	0.24	3.53	0.97	1.08
7	108	36	186	23	17	0.21	2.87	0.74	0.60
II									
8	161	55	284	34	25	0.25	3.53	0.89	1.12
9	154	47	256	30	22	0.20	3.17	0.84	0.83
10	154	54	240	33	25	0.20	3.81	0.86	1.08
11	174	50	249	33	23	0.19	3.38	0.93	1.08
III									
12	163	43	209	23	19	0.15	2.74	0.73	0.84
13	165	47	247	32	23	0.19	3.84	0.75	1.18
14	132	50	251	33	24	0.19	4.05	1.00	0.94
15	136	44	221	28	22	0.18	3.63	0.71	0.90
16	135	43	214	27	21	0.19	3.57	0.75	1.40

I, II, III = 1.0, 1.5, and 2.0 m beds respectively

Table 86. (continued)

Treatment		N	P	K	Ca	Mg	Cu	Zn	Mn	Fe
		kg/ha								
I						1978				
	1	45	20	134	13	15	0.08	0.74	0.37	0.59
	2	67	32	174	18	22	0.11	0.96	0.56	0.95
	3	63	25	130	21	20	0.10	0.79	0.57	0.90
	4	51	21	109	14	14	0.08	0.60	0.50	0.55
	5	52	19	108	12	12	0.07	0.61	0.40	0.70
	6	60	22	143	16	16	0.10	0.86	0.43	0.78
	7	53	23	135	15	15	0.08	0.79	0.43	0.69
II										
	8	63	26	157	15	17	0.09	0.81	0.43	0.69
	9	66	26	145	19	18	0.09	0.84	0.47	0.86
	10	76	28	134	21	21	0.10	0.90	0.45	0.81
	11	57	21	109	13	14	0.07	0.66	0.36	0.57
III										
	12	72	24	164	14	17	0.11	0.91	0.35	0.70
	13	70	24	141	17	19	0.11	0.99	0.42	0.69
	14	72	25	156	11	23	0.10	1.04	0.45	0.80
	15	71	28	144	18	19	0.10	0.98	0.50	0.70
	16	62	27	119	15	17	0.09	0.85	0.44	0.82

I, II, III = 1.0, 1.5, and 2.0 m beds respectively

Table 87. Nutrient content of whole plant samples. Average of 1977 and 1978. Bedding experiments No.6 and 10. At harvest.

Treatment	N	P	K	Ca	Mg	Cu	Zn	Mn	Fe
	kg/ha								
I 1	75	26	149	16	15	0.09	1.52	0.49	0.59
2	84	34	178	22	20	0.14	1.96	0.71	0.91
3	92	34	171	24	20	0.13	1.86	0.75	0.84
4	78	26	143	18	15	0.11	1.50	0.61	0.61
5	79	27	138	17	14	0.12	1.85	0.57	0.70
6	106	36	195	25	20	0.17	2.19	0.70	0.93
7	81	30	161	19	16	0.14	1.83	0.58	0.65
II 8	112	40	220	24	21	0.17	2.17	0.66	0.90
9	110	36	201	24	20	0.14	2.01	0.65	0.85
10	115	41	187	27	23	0.15	2.35	0.66	0.95
11	116	36	179	23	19	0.13	2.02	0.65	0.82
III 12	118	34	186	19	18	0.13	1.82	0.54	0.77
13	117	36	194	24	21	0.15	2.41	0.58	0.94
14	102	38	203	28	24	0.15	2.54	0.72	0.87
15	104	36	183	23	20	0.14	2.30	0.60	0.80
16	99	35	167	21	19	0.14	2.21	0.60	1.11

I, II, III = 1.0, 1.5, and 2.0 beds respectively

Table 88. Correlation coefficients for nutrient concentration and percent IVOMD, in whole plant samples, agronomic variables and nutrient content. Bedding experiment 1977

CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / N = 64

	N	P	K	CA	MG	CU	ZN	MN	FE	IVOMD
					whole plant					
DM	-0.04695 0.7133	0.22997 0.0675	0.08747 0.4919	0.11852 0.3103	0.18315 0.1474	-0.10999 0.3869	0.10516 0.4082	0.09541 0.4533	0.20823 0.0987	-0.32115 0.0075
Grain	0.08673 0.4956	0.05099 0.6837	0.23261 0.0732	0.03930 0.7579	-0.04603 0.7180	-0.14017 0.2693	-0.18813 0.1543	-0.37057 0.0735	-0.15162 0.2336	-0.17316 0.1712
Pt.pop	-0.02645 0.8357	0.07762 0.5421	0.10913 0.3907	0.11255 0.3759	0.04349 0.7329	0.00765 0.9522	0.00136 0.9877	-0.12200 0.3369	-0.02348 0.8549	-0.33761 0.0076
Pt.Nt. Content	-0.21127 0.2038	0.00729 0.9548	-0.02764 0.8204	-0.09662 0.4475	0.04819 0.7042	-0.06875 0.5893	-0.12235 0.3355	0.02055 0.8799	-0.04902 0.7180	-0.07141 0.5746
N	0.83351 0.0001	0.63082 0.0001	0.61668 0.0001	0.56213 0.0001	0.66152 0.0001	0.09389 0.4698	0.22948 0.0681	0.06693 0.5993	0.40496 0.0099	-0.21767 0.0940
P	0.75566 0.0179	0.72212 0.0001	0.47025 0.0001	0.46912 0.0301	0.52317 0.0001	-0.15109 0.2334	0.19345 0.1256	0.29763 0.0169	0.16171 0.0033	-0.38000 0.0023
K	0.34243 0.0056	0.58607 0.0001	0.63745 0.0001	0.51230 0.0001	0.61227 0.0001	-0.09707 0.4454	0.14962 0.2380	0.25339 0.0434	0.36516 0.0052	-0.42763 0.0004
Ca	0.10497 0.1494	0.37778 0.0021	0.29744 0.0174	0.78550 0.0001	0.34771 0.0002	0.07122 0.5760	0.26436 0.0348	0.07132 0.6301	0.33496 0.0017	-0.42792 0.0004
Mg	0.75721 0.0038	0.57150 0.0001	0.45083 0.0002	0.59938 0.0001	0.73422 0.0001	-0.02928 0.8184	0.23319 0.0671	0.21885 0.0823	0.43845 0.0003	-0.34022 0.0059
Cu	-0.04548 0.7212	0.01851 0.8845	0.03054 0.8082	0.44934 0.0002	0.17346 0.1705	0.82004 0.0001	0.19344 0.1141	-0.06222 0.6251	0.16103 0.2037	-0.25069 0.0045
Zn	0.07935 0.5304	0.29053 0.0199	0.13448 0.2934	0.45479 0.0002	0.30321 0.0315	0.01055 0.9315	0.69456 0.0001	0.00090 0.9941	0.41653 0.0006	-0.22747 0.0170
Mn	-0.02237 0.8607	0.10948 0.3968	0.26131 0.0370	0.46752 0.0001	0.28291 0.0235	-0.15606 0.2183	-0.01038 0.9351	0.75496 0.0001	0.24522 0.0508	-0.27886 0.0257
Fe	0.21299 0.0925	0.37038 0.0026	0.26935 0.0414	0.47809 0.0001	0.33176 0.0094	-0.01466 0.1960	0.26049 0.0374	0.16597 0.1893	0.31465 0.0061	-0.17325 0.1564

Table 89. Correlation coefficients for nutrient concentration and percent IVOMD in whole plant samples, agronomic variables and nutrient content. Bedding experiment 1978

CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / N = 64

	N	P	K	CA	MG	CU	ZN	MN	FE	IVDMD
					whole plant					
DM	-0.13110 0.3404	-0.16734 0.1803	-0.05598 0.6604	-0.03656 0.7744	0.07707 0.5953	0.17130 0.1759	0.02188 0.8638	-0.15018 0.2362	-0.15795 0.2126	-0.17093 0.1840
Grain	0.66689 0.0001	-0.02005 0.8750	-0.03107 0.8192	-0.09043 0.4773	0.10953 0.4066	0.04090 0.7494	0.02145 0.8664	-0.20115 0.1106	-0.37353 0.0038	-0.05974 0.6359
Pt.pop	0.23201 0.0661	0.05661 0.6582	0.01561 0.9026	0.35479 0.0422	0.22795 0.0760	0.05915 0.6425	0.11849 0.3515	-0.12923 0.3108	-0.01167 0.9271	-0.10456 0.4143
Pt.Ht	0.19917 0.1157	0.10191 0.4094	0.05499 0.6661	-0.04618 0.7171	0.06981 0.5838	0.06416 0.6145	-0.25877 0.0390	-0.24260 0.0534	0.01015 0.9364	-0.12207 0.3647
N	0.86674 0.0001	0.46231 0.0001	-0.20087 0.1016	0.25820 0.0394	0.48131 0.0001	0.19139 0.1298	-0.21273 0.0915	0.02463 0.8463	0.05573 0.6620	0.19560 0.1216
P	0.51268 0.0001	0.78428 0.0001	0.13916 0.2728	0.41689 0.0137	0.63294 0.0001	0.17425 0.1695	-0.03526 0.7821	0.29500 0.0180	0.19915 0.1133	0.26752 0.0337
K	-0.15963 0.2225	0.04694 0.7128	0.75726 0.0001	-0.20841 0.0934	0.02130 0.8902	-0.04408 0.7045	0.10121 0.4262	-0.13343 0.2971	-0.27798 0.0260	-0.18097 0.1524
Ca	0.34707 0.0490	0.23806 0.0584	-0.22876 0.0690	0.86078 0.0001	0.72910 0.0001	0.20509 0.1040	0.22144 0.0787	0.17238 0.1824	0.37180 0.0025	-0.27412 0.0284
Mg	0.14941 0.2037	0.39024 0.0017	-0.06234 0.6246	0.58765 0.0001	0.81348 0.0001	0.27259 0.0293	0.14611 0.2493	0.26016 0.0379	0.25533 0.0568	-0.07429 0.5597
Cu	0.25706 0.0477	-0.00297 0.9815	-0.12039 0.3482	0.05119 0.6879	0.18499 0.1327	0.68820 0.0001	-0.06913 0.5873	-0.07333 0.5804	0.09247 0.4942	-0.05634 0.6581
Zn	-0.21632 0.0860	-0.12324 0.3320	0.07336 0.5646	0.20347 0.1068	0.19056 0.1115	-0.05345 0.6794	0.87812 0.0001	-0.13434 0.2899	0.03364 0.7820	-0.18453 0.1443
Mn	0.05555 0.6338	0.10932 0.3842	-0.29496 0.0184	0.45877 0.0001	0.46248 0.0001	0.18042 0.1518	-0.05684 0.6555	0.83133 0.0001	0.22713 0.0711	0.01467 0.9265
Fe	0.13591 0.2860	0.23142 0.0658	0.00001 1.0000	0.48793 0.0001	0.46300 0.0001	0.14238 0.2653	0.13203 0.2943	-0.24061 0.0567	0.02180 0.8301	0.03540 0.7662

Table 90. Correlation coefficients for nutrient concentration and percent IVOMD in whole plant samples, agronomic variables and nutrient content. Bedding exp. 1977-1978.

CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / N = 124

	N	P	K	CA	MG	CU	ZN	MN	FE	IVOMD
					whole plant					
DM	0.42663 0.0001	0.41711 0.0001	0.26134 0.0030	0.17047 0.0001	-0.23520 0.0075	0.37861 0.0001	0.07087 0.0001	0.45393 0.0001	-0.13434 0.1394	-0.17513 0.0431
Grain	0.01366 0.8794	-0.03469 0.6975	0.03142 0.6987	-0.07463 0.4325	0.08038 0.3635	-0.10214 0.2467	-0.10481 0.2409	-0.14334 0.0654	-0.09363 0.3376	-0.11431 0.1936
Pt.pop	0.60048 0.0500	0.01465 0.8637	0.01761 0.8514	0.17023 0.0547	0.18612 0.0354	-0.02332 0.7939	-0.03923 0.6602	-0.17290 0.0510	0.12293 0.1747	-0.12469 0.1704
Pt.Ht	-0.42574 0.0001	-0.35949 0.0001	-0.30118 0.0006	-0.34705 0.0001	0.37800 0.0001	-0.45968 0.0001	-0.76284 0.0001	-0.40512 0.0001	0.18880 0.0342	-0.40461 0.0001
N	0.48300 0.0001	0.69693 0.0001	0.43302 0.0001	0.52657 0.0001	-0.04414 0.6208	0.43067 0.0001	0.74019 0.0001	0.41179 0.0001	-0.02209 0.7968	-0.05055 0.5679
P	0.40517 0.0001	0.79250 0.0001	0.45463 0.0001	0.51262 0.0001	-0.01301 0.8841	0.36415 0.0001	0.71021 0.0001	0.43027 0.0001	0.00493 0.9196	-0.11633 0.1910
K	0.21036 0.0001	0.58502 0.0001	0.68278 0.0001	0.37393 0.0001	-0.13693 0.1235	0.35392 0.0001	0.67962 0.0001	0.36152 0.0001	-0.05023 0.5734	-0.23464 0.0074
Ca	0.53293 0.0001	0.55364 0.0001	0.27665 0.0014	0.76274 0.0001	0.05317 0.5843	0.44633 0.0001	0.63962 0.0001	0.43185 0.0001	0.09231 0.4001	-0.26171 0.0029
Mg	0.45621 0.0001	0.55964 0.0001	0.28079 0.0013	0.61708 0.0001	0.50335 0.0001	0.20357 0.0212	0.38120 0.0001	0.34872 0.0001	0.04385 0.6055	-0.21937 0.0129
Cu	0.45478 0.0001	0.48919 0.0001	0.24564 0.0052	0.44981 0.0001	-0.23922 0.0065	0.86760 0.0001	0.72267 0.0001	0.33835 0.0001	-0.10316 0.2494	-0.16704 0.0595
Zn	0.56842 0.0001	0.53317 0.0001	0.34776 0.0001	0.47864 0.0001	-0.29014 0.0009	0.51703 0.0001	0.94833 0.0001	0.43329 0.0001	-0.10512 0.2376	-0.09738 0.2742
Mn	0.15019 0.0001	0.58573 0.0001	0.27051 0.0020	0.14737 0.0001	-0.10319 0.2228	0.34468 0.0001	0.64307 0.0001	0.41074 0.0001	-0.02284 0.7983	-0.17061 0.1761
Fe	0.31496 0.0001	0.33284 0.0001	0.23105 0.0101	0.48412 0.0001	0.22317 0.0117	0.12893 0.0764	0.36135 0.0001	0.20252 0.0008	0.72116 0.0001	-0.11324 0.2031

These studies agree with literature sources (41, 46) that point out that bed and plant population modifications are adequate alternatives. The yield increase and the low cost of the new operations involved could justify the change from the traditional 1 m bed. If farmers do not wish to change bed width, the inclusion of double rows in the traditional 1.0 m beds would bring an important improvement.

Cultivar Experiments

These experiments included 6 grain sorghum and 2 forage sorghum hybrids. Soil test were made prior to planting each year. Data are shown in Tables 91 and 92. Means for agronomic variables and nutrient concentration of whole plant samples are presented in Tables 93 and 94. Hybrids No. 3 and 7 (Dekalb D-60 and Dekalb A-26) did very poorly and were excluded from the combined statistical analysis. Hybrid No. 8 (Dekalb E-59 in 1977 and Grower ML-135) were also excluded.

Significant variables as determined by the F test appear in Table 95. There were only differences due to cultivar and to the year (Table 96).

Differences in nutrient concentration of whole plant samples, percent IVOMD, dry matter, and grain yields (when applicable) are shown in Tables 97, 98, 99, and 100. From the combined analysis, it is clear that hybrids No. 2, 4, and 5 had the highest N and P concentrations. Cultivars No. 1 and 6 (forage sorghum) had the highest dry matter yields, 10,816 and 11,243 kg/ha respectively. Grain yield was difficult to evaluate due to missing values. However, hybrid No. 4 (Dekalb BR-54) and No. 8 in 1978 (Grower ML-135) would probably be the best choices for the area considering overall performance. There were no differences in percent

Table 91. Soil analysis before planting. Sorghum cultivars experiment No.6, 1977

Rep.	pH	P	K	Ca	Mg	Cu	Zn	Mn	Fe
		ppm							
I	4.9	344	90	836	65	3.64	6.5	4.8	66
II	5.1	368	73	810	52	3.64	6.8	4.9	64
III	5.1	351	76	750	45	3.68	6.4	4.7	62
IV	4.9	357	94	914	56	4.04	7.9	5.6	66
$\bar{X}$		355	83	827	54	3.75	6.9	5.0	64

Table 92 Soil analysis before planting. Sorghum cultivars experiment No.11, 1978

Rep	pH	P	K	Ca	Mg	Cu	Zn	Mn	Fe
		ppm							
I	5.4	300	112	672	76	3.8	7.6	3.2	52
II	5.3	264	52	608	68	3.7	7.6	3.1	48
III	5.6	274	72	600	76	3.0	6.4	3.0	44
IV	5.4	274	60	640	72	3.2	6.4	3.2	40
$\bar{X}$		278	74	630	73	3.4	7.0	3.1	46

Table 93. Nutrient concentration in whole plant samples and agronomic variables for cultivars excluded from the statistical analysis. Cultivar experiments No.7 and 11, 1977 and 1978

Cult.	Nutrient concentration at harvest									Dry matter yield kg/ha	Percent IVOMD	Grain yield kg/ha
	N	P	K	Ca	Mg	Cu	Zn	Mn	Fe			
	%					ppm						
					1977							
3	1.27	0.43	1.60	0.30	0.27	12	285	88	72	1869	57.24	
7	1.32	0.50	2.12	0.29	0.26	12	305	112	90	1615	51.36	
8	1.39	0.50	2.11	0.31	0.26	14	292	100	85	3166	51.32	
					1978							
3												
7	1.05	0.45	2.20	0.21	0.24	19	62	71	120	2637	59.19	242
8	0.81	0.31	1.59	0.18	0.20	16	55	50	75	7600	58.47	1353

Table 94. nutrient concentration in whole plant samples, and agronomic variables for cultivars included in the statistical analysis. Cultivar experiments No.7 and 10, 1977 and 1978

Cult.	Nutrient concentration at harvest									Dry matter yield	Percent	Grain yield
	N	P	K	Ca	Mg	Cu	Zn	Mn	Fe	kg/ha	IVOMD	kg/ha
	%					ppm						
					1977							
1	0.83	0.32	1.76	0.32	0.26	12.2	245	68	72	8797	50.64	
2	1.17	0.43	2.15	0.29	0.26	12.7	307	100	77	2128	50.87	
4	1.39	0.46	1.93	0.28	0.24	12.7	290	77	67	3239	56.71	
5	1.22	0.45	2.06	0.27	0.22	13.0	300	96	87	2904	52.37	
6	0.86	0.31	1.83	0.27	0.24	10.5	272	72	52	8674	48.62	
					1978							
1	0.50	0.22	1.46	0.16	0.20	8.3	49	29	50	13507	58.55	497
2	0.93	0.33	1.30	0.15	0.23	13.7	58	51	105			
4	0.61	0.28	1.65	0.17	0.18	11.5	55	45	82	8024	56.13	1368
5	0.67	0.29	1.67	0.15	0.19	12.5	52	39	67	7991	60.69	1206
6	0.54	0.21	1.47	0.15	0.21	12.7	43	31	42	13811	57.64	

Table 95. Significant variables as determined by F test. Combined analysis 1977, 1978. Cultivar experiments No.7 and 11

Source	D.F	N	P	K	Ca	Mg	Cu	Zn	Mn	Fe	IVOMD	Dry matter	Grain
	F-test on whole plant nutrients concentration, percent IVOMD, and dry matter and grain												
						1977-1978							
Rep	3												
Variety	4	0.0001	0.0040			0.0132			0.0207	0.0097		0.0001	
Rep x Var	12												
Yr	1	0.0001	0.0001	0.0136	0.0001	0.0079		0.0001	0.0001		0.0001	0.0001	
Var x Yr	4												
						1977							
Rep	3												
Variety	4	0.0001	0.0327							0.0001		0.0001	
						1978							
Rep	3												
Variety	4	0.0055	0.0006							0.0411	0.0175	0.0001	0.0001

Table 96. Effect of year on nutrient concentration of whole plant samples. Cultivar experiments No.7 and 11, 1977 and 1978

Year	Nutrient concentration in whole plant samples at harvest									Dry matter yield kg/ha	Percent IVOMD
	N	P	K	Ca	Mg	Cu	Zn	Mn	Fe		
	----------%----------					----------ppm----------					
77	1.09 a	0.39 a	1.95 a	0.29 a	0.25 a	12.2 a	283 a	83 a	71 a	5148 b	5148 b
78	0.66 b	0.27 b	0.51 b	0.16 b	0.20 b	11.9 a	52 b	40 b	70 a	10655 a	59.16 a

Means followed by different letters are significantly different according to Duncan's multiple range test. Comparisons should be made within columns.

Table 97. Nutrient concentration of whole plant samples. Combined analysis. Cultivar experiments No. 7 and 11, 1977 and 1978

Cultivar	Nutrient concentration								
	N	P	K	Ca	Mg	Cu	Zn	Mn	Fe
	----------%----------					----------ppm----------			
1	0.69 b	0.28 b	1.63 a	0.26 a	0.23 a	10.6 a	161 a	51 c	63 bc
2	1.05 a	0.38 a	1.73 a	0.22 a	0.25 a	13.2 a	183 a	79 a	91 a
4	1.00 a	0.37 a	1.79 a	0.23 a	0.22 a	12.1 a	173 a	61 bc	75 ab
5	0.95 a	0.37 a	1.86 a	0.21 a	0.21 a	12.7 a	176 a	68 ab	77 ab
6	0.70 b	0.27 b	1.65 a	0.21 a	0.23 a	11.6 a	158 a	52 c	47 c

Means followed by different letters are significantly different according to Duncan's multiple range test. Comparisons should be made within columns.

Table 98. Nutrient concentration of whole plant samples. Cultivar experiment, 1977

Cultivar	Nutrient concentration								
	N	P	K	Ca	Mg	Cu	Zn	Mn	Fe
	----------%----------					----------ppm----------			
1	0.83 c	0.32 b	1.76 a	0.33 a	0.26 a	12.2 ab	245 b	68 c	72 bc
2	1.17 b	0.43 ab	2.15 a	0.29 a	0.26 a	12.7 a	307 a	100 a	77 b
4	1.40 a	0.46 a	1.93 a	0.28 a	0.24 a	12.7 a	290 ab	77 abc	67 c
5	1.22 ab	0.45 a	2.06 a	0.27 a	0.22 a	13.0 a	300 a	96 ab	87 a
6	0.86 c	0.32 b	1.84 a	0.27 a	0.24 a	10.5 b	272 ab	72 bc	52 d

Means followed by different letters are significantly different according to Duncan's multiple range test. Comparisons should be made within columns.

Table 99. Nutrient concentration of whole plant samples. Cultivar experiment, 1978

Cultivar	Nutrient concentration at harvest								
	N	P	K	Ca	Mg	Cu	Zn	Mn	Fe
	----------%----------					----------ppm----------			
1	0.50 b	0.22 c	1.47 ab	0.16 a	0.20 ab	8.3 b	49 ab	29 b	50 b
2	0.93 a	0.33 a	1.30 b	0.16 a	0.23 a	13.7 a	58 a	51 a	105 a
4	0.61 b	0.28 b	1.65 a	0.17 a	0.19 b	11.5 ab	55 ab	45 ab	82 ab
5	0.68 b	0.29 ab	1.67 a	0.15 a	0.20 ab	12.5 ab	52 ab	40 ab	67 ab
6	0.54 b	0.21 c	1.47 ab	0.15 a	0.21 ab	12.7 ab	44 b	31 b	42 b

Means followed by different letters are significantly different according to Duncan's multiple range test. Comparisons should be made within columns.

Table 100. Percent IVOMD, dry matter, and grain yields. Cultivar experiments No.7 and 11, 1977, 1978

Cultivar	IVOMD			Dry matter yield			Grain yield
	1977	1978	Average	1977	1978	Average	1978
	----------%----------			----------kg/ha----------			
1	50.64 ab	58.55 abc	54.03 a	8794 a	13507 a	1081 a	
2	50.87 ab	62.63 a	56.75 a	2128 b		2128 c	497 b
3	56.71 a	56.14 c	56.42 a	3240 b	8024 b	5632 b	1367 a
5	52.37 ab	60.70 ab	56.53 a	2904 b	7991 b	5447 b	1207 a
6	48.62 b	57.64 bc	53.13 a	8674 a	13811 a	11243 a	

Means followed by different letters are significantly different according to Duncan's multiple range test. Comparisons should be made within columns.

IVOMD in the combined analysis. However, on the separate analysis hybrid No. 4 in 1977 and hybrid No. 2 in 1978 presented the higher IVOMD values.

Nutrient content values are presented in Table 101. Cultivars No. 1 and 6 (forage sorghum) showed the highest N, P, and K content values for both years. Grain hybrids No. 4, 5, and 8 presented intermediate values, while hybrids No. 2, 3 and 7 had the lowest content.

The importance of sorghum, especially as a forage crop, probably needs to be stressed in this area. The N removed in relation to N applied was almost 100% for the forage sorghum (cultivar No. 1 and 6) as shown in Table 102. If the crop was chopped and returned to the soil, it would mean an enhancement to the soil fertility, and a benefit for the next crops. If used as forage, it represents a valuable source of feed as illustrated by the recycling of nutrients, and the digestible dry matter yield presented in Table 103.

Table 101. Nutrient content of whole plant samples. Cultivar experiments No.7 and 11, 1977 and 1978

Cultivar	N	P	K	Ca	Mg	Cu	Zn	Mn	Fe
	kg/ha								
					1977				
1	73.0	28.1	154.8	28.1	22.9	0.11	2.15	0.60	0.63
2	24.9	9.1	45.7	6.1	5.5	0.03	0.65	0.21	0.16
3	22.6	8.0	29.9	5.6	5.0	0.02	0.53	0.16	0.17
4	45.0	14.9	62.5	9.1	7.7	0.04	0.94	0.25	0.22
5	35.0	13.1	59.8	7.8	6.4	0.03	0.87	0.28	0.25
6	74.6	26.9	158.7	23.4	20.8	0.09	2.35	0.62	0.45
7	21.3	8.1	34.2	4.7	4.2	0.02	0.47	0.16	0.14
8	44.0	15.8	66.8	9.8	8.2	0.04	0.92	0.32	0.27
					1978				
1	67.5	29.7	197.2	21.6	27.0	0.11	0.66	0.39	0.68
2									
3									
4	48.9	22.5	132.4	13.6	14.4	0.09	0.44	0.36	0.66
5	53.5	23.2	133.4	12.0	15.2	0.10	0.42	0.31	0.53
6	74.6	29.0	203.0	20.7	29.0	0.17	0.59	0.43	0.58
7	27.7	3.7	58.0	5.5	6.3	0.05	0.16	0.19	0.32
8	61.6	23.6	120.8	13.7	15.2	0.12	0.42	0.38	0.57

Table 102. Percentage of N removed in relation to N applied. Cultivar experiment No.7 and 11, 1977 and 1978

Year	Cultivars							
	1	2	3	4	5	6	7	8
	percent N removed							
1977	97	33	30	60	47	99	28	59
1978	90	-	-	65	71	99	37	82

Table 103. Recycling of N, P, and K, and digestible dry matter. Forage sorghum hybrids. Cultivar experiments No.6 and 10, 1977 and 1978

Cultivar	dry matter	Concentration			Nutrient recycled [1]			Digestible dry matter yield [2]
		N	P	K	N	P	K	
	kg/ha	---------%----------			----------kg/ha-------			-----kg/ha-----
				1977				
1	8797	0.83	0.32	1.76	73.0	28.1	154.8	4454
6	8674	0.83	0.31	1.83	74.6	26.9	158.7	4217
				1978				
1	13507	0.50	0.22	1.46	67.5	29.7	197.2	7908
6	13811	0.54	0.21	1.47	74.6	29.0	203.0	7960

[1] Recycled = dry matter x nutrient concentration

[2] Digestible dry matter yield = IVOMD x dry matter

The pages in this thesis have been misnumbered

and there is no page 135.

CONCLUSIONS

Studies on fertility, bedding and cultivar management of sorghum and fertility of corn were conducted for two years in the Hastings area of Florida. These experiments were grown in Rutlege fine sand (Sandy, Siliceous, Thermic family of the Typic Humaquepts). Data from these studies provided information on plant nutrient element relationships in soil and plant samples, as well as on alternative management over traditional farm practices to improve yield.

In the fertility experiments N affected grain and dry matter yields as well as nutrient relationships in all collected samples. In all cases the first N increment was sufficient to maximize yields under the management levels of these studies. Improvements in irrigation, weed, pest control, and plant population management could result in a need for higher N rates, in order to obtain higher yields. Economic considerations would also play an important part in the decision making process.

Results from these studies showed that the percent N removed in relation to N applied was higher at the 0 and 100 kg N/ha rate. It was observed that high N rates caused a drop in pH and extractable nutrients in the soil, and an increase in N, Ca, Mg, Zn, and Mn in the leaves and whole plant samples.

Phosphorus and K fertilization of the crops on old vegetable land tended to decrease grain and dry matter yields, suggesting salinity problems and possibly nutrient toxicity. The effect of the previous

fertilization of vegetable crops contributed to this problem. Potassium showed ion antagonism in several cases. Fertilizer K decreased Mg concentration and content in plant samples, similar results occured with N, P, and Ca. Magnesium and Mn showed good correlations with other elements. Magnesium in the leaves was negatively correlated with K, Ca, Mg, and Zn concentrations in the soil.

Use of the traditional 1.0 m potato bed resulted in an apparent waste of space and yield reduction for the sorghum crop. All modifications imposed in the 1.0 m beds and in the new 1.5 and 2.0 beds resulted in improved yields. Highest grain yield (19% average increase) was obtained from the 2.0 m beds. The highest yield (40% increase over the control) was from the 2.0 m bed four rows treatment. Total sorghum plant dry matter was also higher in 1.5 and 2.0 m beds. Nitrogen removal in relation to N applied in the bedding studies was very high, 233% for the 1.5 m bed broadcast treatment in 1977 and 101% for the 1.5 m bed five rows treatment in 1978, reflecting the N uptake of the sorghum crop in this sandy soil.

The cultivar experiments demonstrated the potential of sorghum as a forage crop for the area. The cultivar Dekalb FS-24 removed almost 100% of the N applied and recycled 74, 29, and 203 kg/ha of N, P, K, respectively.

Several concluding remarks giving step by step management for growing sorghum and corn follow.

Grain Sorghum

1. Grain sorghum should be planted in double rows on the traditional 1.0 m beds. Beds should be knocked down sufficiently for rows to be about 25 cm apart on each bed. Another alternative is to plant 3 rows 50 cm apart on 2.0 m beds.
2. A rate of 100 kg N/ha should be applied to grain sorghum, one half at planting and one half sidedress.
3. Phosphorus or K fertilizer should not be applied on old vegetable land unless soil tests suggests otherwise.
4. The most appropriate sorghum varieties were Dekalb BR-54 or Grower M1-135 for grain and Dekalb FS-25A or FS-24 for forage.
5. Weeds in sorghum should be controlled by use of timely cultivation and/or herbicides. Atrazine and Propachlor gave good control when applied at planting. Other herbicides like paraquat applied post directed 4-6 weeks after planting could also be very effective.
6. Grain sorghum should be planted as early as possible after potatoes to avoid damage by sorghum "midge."
7. If rainfall is not sufficient, irrigation should be considered as an essential management practice to make a crop of grain sorghum.
8. The third leaf from the top of the sorghum plant can be used to monitor nutrient-element concentration for proper fertilization requirements. Fifteen to 20 leaves over the affected area should be taken at mid bloom of the sorghum.
9. Whole plant samples should be taken just prior to grain harvest to determine dry matter production, plant-nutrient uptake, and recycled plant-nutrients.

Corn

1. A recommended hybrid should planted on the traditional 1.0 m beds in single rows. The Florida Cooperative Extension Service recommendations should be followed.
2. One-hundred kg N/ha should be applied to corn grain, one half at planting and one half sidedress.
3. Phosphorus or K fertilizer should not be used on old vegetable land unless soil test suggests otherwise.
4. Timely cultivation and/or use of herbicides should be considered as an essential part of the management program. Post directed application of Evick + 2,4 D provided good control under the conditions of this study.
5. Irrigation should also be used during the life cycle of corn if rainfall is inadequate.
6. The ear leaf of the corn plant can be used to monitor nutrient-element concentration for proper fertilization requirements. Fifteen to 20 leaves over the affected area should be taken at silk time. Assistance should be obtained through the county agent.
7. Whole plant samples should be taken just prior to grain harvest to determine dry matter production, plant-nutrient uptake, and recycled plant-nutrients.

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He is married to Lorna Vega Rojas and they have two children, Elena and Javier.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Raymond Noel Gallaher
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